**3GPP TSG-RAN WG4 Meeting # 109 (Draft)R4-23XXXXX**

**Chicago, USA, November 13 – November 17, 2023**

**Agenda item:** 8.12.4

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

**Title:** Topic summary for [109][214] NR\_HST\_FR2\_enh (Part 1)

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion (e.g. list of treated agenda items) and provide some guidelines for email discussion if necessary.*

This summary provides the overview and captures the open issues based on the TDoc submitted to RAN4#109 meeting into the following AIs**:**

* 8.12.1 RRM core requirement maintenance [NR\_HST\_FR2\_enh-Core]
	+ 8.12.1.1 Simultaneous multi-panel operation for train roof-mounted FR2 high power devices [NR\_HST\_FR2\_enh-Core]
	+ 8.12.1.2 Intra-band carrier aggregation (CA) scenario [NR\_HST\_FR2\_enh-Core]
	+ 8.12.1.3 UL timing adjustment solutions [NR\_HST\_FR2\_enh-Core]
	+ 8.12.1.4 RRM aspects for tunnel deployment scenario [NR\_HST\_FR2\_enh-Core]
	+ 8.12.1.5 Others

The previous WFs on the topic from RAN4#108 are:

* R4-2317392, WF on FR2 HST RRM core requirement maintenance, Nokia, Nokia Shanghai Bell, RAN4#108bis, Xiamen, China, October 09 – October 13, 2023.
* R4-2314297, WF on FR2 HST RRM requirements (part 1), Samsung, RAN4#108, Toulouse, France, August 21st – 25th, 2023.
* R4-2314298, WF on FR2 HST RRM requirements (part 2), Nokia, Nokia Shanghai Bell, RAN4#108, Toulouse, France, August 21st – 25th, 2023.

The latest RRM Core requirements related to the HST FR2 Enhanced are captured in the big CR:

* R4-2313541, Big CR to TS38.133 on enhanced NR support for FR2 HST, Samsung, RAN4#108, Toulouse, France, August 21st – 25th, 2023.

# Topic #1: RRM Core requirement maintenance

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

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2319941](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319941.zip) | Intel Corporation | **Feature list proposals for HST FR2 enhancements**This paper summarizes our proposals for general principles and the specific feature groups in Rel-18 HST FR2 enhancement work item.[Moderator]: Due to the size of the paper, it will be considered in the proposals. |
| [R4-2318816](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2318816.zip) | Ericsson | **Multi-panel operation in HST FR2****Proposal 1:** We lean towards Option2: add a new component to FR2 HST feature group in Rel-18. |
| [R4-2319817](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319817.zip) | Nokia, Nokia Shanghai Bell | **On HST FR2 Enhanced Simultaneous Two-Panel Reception RRM Maintenance****Proposal 1**: To support PC6 UE capability for simultaneous two-panel reception in HST Enhanced Rel-18 in the feature list, RAN4 needs either 1) to define a new dedicated feature group in Rel-18 or 2) to update existing Rel-17 feature group (22-1) in Rel-18 by adding a new component for simultaneous reception. |
| [R4-2318815](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2318815.zip) | Ericsson | **CA operation in HST FR2****Proposal 1**: Keep Core requirement. No test case for the 3ms activation delay in the HST FR2 Rel-18 performance part is needed.**Proposal 2**: We have concern on early measurement reporting, the applicability of early measurement shall be checked in advance. |
| [R4-2319378](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319378.zip) | Huawei, HiSilicon | **Discussion on intra-band CA in FR2 eHST**Observation 1: The SSB-less and SSB-based SCell activation performance are almost the same. Observation 2: For PC6 UE, supporting scellWithoutSSB can be a default capability, and it has NO need to perform additional SSB based fine synchronization even if SSB is configured on the being activated SCell. Observation 3: No need to introduce new capability to support 3ms SCell activation for PC6 UE. **Proposal**: No additional capability and condition are needed for PC6 supporting 3ms SCell activation in FR2 intra-band HST scenario. |
| [R4-2319717](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319717.zip) | Samsung | **Discussion on feature list and CA remaining issues for Rel-18 FR2 HST**Proposal 1: RAN4 to introduce a new feature group 34-1 for FR2 HST with simultaneous DL reception with two different QCL TypeD RSs as optional with capability signaling to indicate the supported simultaneous reception with different QCL Type-D RSs in NR FR2 HST with: * Feature 22-1 and 16-2c as the prerequisite feature groups for the new 34-1
* “Support of enhanced RF requirements”, “ Support of enhanced RRM measurement requirements, including the enhanced requirement of SSB-based Layer-1 measurement and the support of MRTD requirement for FR2-1 PC6 UEs with simultaneous DL reception with two different QCL TypeD RSs specified in TS38.133”, and “Support of enhanced demodulation processing” to support FR2-1 PC6 UEs with simultaneous DL reception with two different QCL TypeD RSs as specified in TS 38.133 as 34-1 feature group components

Proposal 2: For SCell activation delay for PC6 UE, keep the core requirements but do not define any test cases for such requirement. Proposal 3: It is necessary to distinguish UE feature and UE capabilities for inter-frequency idle mode and connected mode. Proposal 4: RAN4 to introduce a new feature group 34-2 for FR2 HST CA as optional with capability signaling to indicate the supported CA and inter-frequency measurement in connected mode for FR2 HST enhancement with: * Feature 22-1 as the prerequisite feature groups for the new 34-2
* “Support of the enhanced RRM for requirement CA in connected mode to support FR2 high speed up to 350 km/h, as specified in TS 38.133” and “Support of the enhanced RRM for inter-frequency in connected mode to support FR2 high speed up to 350 km/h, as specified in TS 38.133” as 34-2 feature group components.

Proposal 5: RAN4 to indicate the support of FR2 HST idle/inactive mode inter-frequency measurement enhancements is an optional UE feature without capability signaling. Proposal 6: There is no need to separate capabilities for idle/inactive measurement reporting in FR2 HST CA. Proposal 7: RAN4 to introduce a new feature group 34-4 for FR2 HST enhanced UL timing adjustment as optional with capability signaling to indicate the supported enhanced one shot large UL timing adjustment with: * Feature 22-2 Support of one shot large UL timing adjustment as the prerequisite feature groups for the new 34-4
* “Support of one shot large UL timing adjustment with 1 bit MAC-CE based cross-RRH indication” and “Support of TCI state switching delay measurement with 1 bit MAC-CE based cross-RRH indication” as 34-4 feature group components.
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| [R4-2319818](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319818.zip) | Nokia, Nokia Shanghai Bell | **On HST FR2 Intra-band carrier aggregation RRM Maintenance**Observation 1: Technical benefit of specifying the new requirement with a shorter activation time is “2 ms + TFirstSSB” faster activation.Observation 2: No test cases were defined for “3 ms” SCell activation delay. SCellwithouSSB is mandatory with capability signalling for intra-band CA, i.e., shall be supported by default but may not be supported yet by the UEs.Observation 3: Enhanced requirement for HST FR2 is not justified enough when the existing requirement with the “SCellwithoutSSB” capability can be re-used.**Proposal 1**: The SCell activation delay requirement does not need to be enhanced for Rel. 18 PC6 UEs by default, i.e., SCellwithoutSSB can still be used as an additional conditions for shorter activation delay.**Proposal 2**: A new Activation delay test shall be introduced if the requirement does not have SCellwithoutSSB as a condition.Observation 4: Rel. 17 specified the HST FR1 CA related capabilities as three separate capabilities. Separate feature definition for idle mode enhancements is mainly related to this feature being an optional feature without capability signaling as this feature is expected to work in idle mode. **Proposal 3**: Define the support for RRM requirements and inter-frequency measurements requirements for Connected and Idle mode as separate features.Observation 5: The carrier aggregation related benefit of inter-frequency measurements in idle mode is the early CA setup that enables fast increased throughput, using the idle/inactive measurement enhancement. Observation 6: Cell re-selection is a procedure supported by all the UEs and is not related to CA directly, whereas EMR support requires NW configuration and additional UE capability.**Proposal 4**: Indicate the support for inter-frequency measurements requirements for idle mode measurement enhancement for early measurement reporting in idle and Inactive mode as a separate capability. |
| [R4-2318817](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2318817.zip) | Ericsson | **UL timing adjustment solutions for HST FR2****Proposal 1**: We slightly prefer Option 2. ‘The UE capability [highSpeedTCISwitchEnhMAC-CE-FR2-r18] to support of Rel-18 enhanced MAC-CE indication may be introduced as a new feature group: optional with capability signalling and with 22-1 Support of FR2 HST as a prerequisite.’ **Proposal 2**: We’re open to Option 1 or other solutions which apply the mechanism to DL TCI state switch here for UL spatial relation switch . **Proposal 3**: Accept RAN2’s proposal in R2-2311619, i.e., design new MAC CE to only correspond to case “1” as presented in R4-2314299, otherwise the UE shall check downlink timing difference. |
| [R4-2319819](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319819.zip) | Nokia, Nokia Shanghai Bell | **Draft LS Reply to RAN4 on UL Timing Adjustment Solutions in HST FR2**Observation 1: RAN2 in the reply LS wrongly assumes that “case “0” seemed to be similar to behaviour of UE in case of receiving the legacy MAC CE” and that “NW can send legacy MAC CE to the UE when NW thinks the timing difference is not large”. However, in Rel-17, legacy “TCI State Indication for UE-specific PDCCH MAC CE” is already used in HST FR2 scenario for PC6 UEs when there is large timing difference between DL signals from two non-collocated RRHs.**Proposal 1**: PC6 UE behaviour in Rel-18 shall stay the same as it was in Rel-17 when legacy MAC CE TCI state switch indication for PDCCH is received (i.e., as described in Rel-17 Clause 7.1.2.3 and 8.10.3A in TS 38.133).Observation 2: The case when MAC-CE indicates “0” contains more significant changes to the legacy Rel-17 PC6 UE behaviour in comparison to the case “1” because in Rel-17 the possibility of large propagation delay difference was already considered, and DL time deference needs to be evaluated in any case. Moreover, in Case “1” TCI state switch delay does not need to be changed from Rel-17 either.**Proposal 2**: If it is agreed to keep a single case for the new MAC CE indication with the same payload as “TCI State Indication for UE-specific PDCCH MAC CE” with eLCID, then only Case “0” shall be used.**Proposal 3**: RAN4 to prepare the LS reply to RAN2 based on the draft from the appendix of this paper.Observation 3: One shot large UL timing adjustment for FR2 Power Class 6 UE and MAC-CE based TCI state switch delay in HST FR2 scenarios are enhanced in Rel-18 if the UE indicates to support [highSpeedTCISwitchEnhMAC-CE-FR2-r18] and [R18 enhanced MAC-CE indication] is indicated. Hence, [highSpeedTCISwitchEnhMAC-CE-FR2-r18] UE capability should not depend on the Support of one shot large UL timing adjustment only.**Proposal 4**: Extend the existing 22-1 feature group (Support of FR2 HST operation) with the component corresponding to the support of R18 enhanced MAC-CE indication.**Proposal 5**: The UE capability [highSpeedTCISwitchEnhMAC-CE-FR2-r18] to support of R18 enhanced MAC-CE indication may be introduced as a new feature group: optional with capability signalling and with 22-1 Support of FR2 HST as a prerequisite. |
| [R4-2319964](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319964.zip) | Huawei, HiSilicon | **Discussion on UL timing adjustment for R18 FR2 HST**Proposal 1: There is no need to define additional UL transmit timing adjustment at UL spatial relation switch, and the existing timing adjustment requirements can be applied. |
| [R4-2319821](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319821.zip) | Nokia, Nokia Shanghai Bell | **On UL Spatial Relation Swithing and Tunnel Deployment Maintenance**Observation 1: For the multi-panel reception in the tunnel scenario, if the UL is transmitted toward the RRH having the beam orientation opposite to the train travelling direction, then the UL will be disrupted in the case of beam/link failure next to the RRH.Observation 2: If UL spatial relation has to be switch always together with TCI state switch (regardless of the UE panel) a performance degradation in UL is observed because UL cannot be configured for transmission towards the best RRH.Observation 3: Decoupling of DL TCI state and UL Spatial relation switches does not completely resolve the issue because independent UL Spatial relation switch might be also associated with a large change in UL Tx timing.**Proposal 1**: If UL TX timing adjustment at UL spatial relation switch is agreed in Rel-18 for HST FR2 scenario, RAN4 to shall agree that UL spatial relation switch shall always be executed strictly with the corresponding DL TCI state switches and performance degradation in UL is acceptable.**Proposal 2**: RAN4 to consider introducing one shot UL timing adjustment procedure at UL Spatial relation switch in HST FR2 deployments with simultaneous two panel reception. |
| [R4-2319721](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319721.zip) | Samsung | **Discussion on MAC-CE based indication for Cross-RRH TCI state switch and Reply to LS**Observation 1: It is RAN2 understanding that if “0” does not indicate any extra new information except the legacy behavior, a new 1 bit (e)LCID can totally correspond to the intention of MAC CE with “1”, and there is no need to design a new MAC CE with an extra octet indicating value “1” or value “0”.**Proposal 1**: The extra NW information, i.e., the upcoming TCI state switching information, is not necessary to be included in the 1 bit MAC-CE indication signalling.**Proposal 2**: “0” in our RAN4 1 bit MAC-CE indication only indicate the intention of “legacy” requirementsFor RAN4’s reply to RAN2 LS (R2-2311615), the following proposals are provided: **Proposal 1**: RAN4 provide the following reply to question raised in RAN2 LS:* It would be possible to design a new MAC CE to only correspond to case “1” as presented in R4-2314299
	+ It is possible to combine a new 1 bit (e)LCID with same contents of the legacy MAC CE (legacy MAC CE format) to design the MAC-CE based indication for cross-RRH TCI state
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| [R4-2318814](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2318814.zip) | Ericsson | **Reply LS on MAC-CE Based Indication for Cross-RRH TCI State Switch** |

### CRs and Draft CRs

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| **T-doc number** | **Company** | **Proposals / Observations** | **Comments** |
| [R4-2318866](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2318866.zip) | Xiaomi | CR on HST Requirements for SSB based BFD | draftCR |
| [R4-2319130](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319130.zip) | Intel Corporation | Maintenance CR on MRTD requirements for HST FR2 multi-panel Rx UE-s | CR |
| [R4-2319963](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319963.zip) | Huawei, HiSilicon | CR on L1-RSRP requirements for R18 FR2 HST | CR |
| [R4-2320990](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2320990.zip) | Qualcomm | CR on RLM requirements for R18 FR2 HST | CR |
| [R4-2319379](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319379.zip) | Huawei, HiSilicon | Update on SCell activation for R18 FR2 HST CA | CR |
| [R4-2319716](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319716.zip) | Samsung | Correction to FR2 HST inter-frequency measurement requirements in Idle mode | draftCR |
| [R4-2319820](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319820.zip) | Nokia, Nokia Shanghai Bell | CR for 38.133: UL TX Timing and TCI State Switch Delay Requirements with New MAC CE (Rel-18, Cat C) | CR |
| [R4-2319131](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319131.zip) | Intel Corporation | Maintenance CR on IDLE mode HST FR2 UE mobility | CR |

## Open issues summary

*Before Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 1-1: Rel-18 PC6 UE feature list for HST FR2 Enhanced

*Sub-topic description:*

In this sub-topic the proposals related to the UE feature list are collected.

HST FR2 Rel-17 features are listed below:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Features** | **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 supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | **Need of FDD/TDD differentiation** | **Need of FR1/FR2 differentiation** | **Capability interpretation for mixture of FDD/TDD and/or FR1/FR2** | **Note** | **Mandatory/Optional** |
| 22.NR\_HST\_FR2 | 22-1 | 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 |  | Yes | No | UE does not meet FR2 high speed train scenario | Per Band | NO | FR2 only | N/A | FR2 UE power class PC6 signalling is used to indicate support of feature group | Optional with capability signalling |
| 22. NR\_HST\_FR2 | 22-2 | Support of one shot large UL timing adjustment | 1) Support of one shot large UL timing adjustment | 22-1 | Yes | No | UE does not support one shot large UL timing adjustment | Per Band | NO | FR2 only | N/A |  |  Optional with capability signaling |

Rel-17 NR\_HST\_FR1\_enh feature list from TR 38.822

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Field name in TS 38.331 [2] | Parent IE in TS 38.331 [2] | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Note | Mandatory/Optional |
| 18. NR\_HST\_FR1\_enh | 18-1 | Enhanced RRM requirements specified for CA for FR1 HST | Support of the enhanced RRM for requirements CA to support FR1 high speed up to 500 km/h, as specified in TS 38.133 | Rel-16 RAN4 feature 10-1 or 10-4 | *measurementEnhancementCA-r17* | *HighSpeedParameters-v1700* | NO | FR1 only |  | Optional with capability signalling |
| 18. NR\_HST\_FR1\_enh | 18-2 | Enhanced RRM requirements specified for inter-frequency measurement in connected mode for FR1 HST | Support of the enhanced RRM requirements for inter-frequency measurement in connected mode to support FR1 high speed up to 500 km/h, as specified in TS 38.133 | Rel-16 RAN4 feature 10-1 or 10-4 | *measurementEnhancementInterFreq-r17* | *HighSpeedParameters-v1700* | NO | FR1 only |  | Optional with capability signalling |
| 18. NR\_HST\_FR1\_enh | 18-3 | Enhanced RRM requirements specified for inter-frequency measurement in Idle and Inactive mode for FR1 HST | Support of the enhanced RRM requirements for inter-frequency measurement in idle and Inactive mode to support FR1 high speed up to 500 km/h, as specified in TS 38.133 |  | n/a | n/a | NO | FR1 only |  | Optional without capability signalling |
| 18. NR\_HST\_FR1\_enh | 18-4 | Support of enhanced Demodulation requirements for CA in HST SFN FR1 | 1) Support of demodulation processing for HST SFN CA scenario in FR1 | Rel-16 RAN4 feature 10-2 | *demodulationEnhancementCA-r17* | *CA-ParametersNR-v1700* | No | FR1 only |  | Optional with capability signalling |

#### Issue 1-1-1: UE features for simultaneous two-panel reception

* Background:
	+ Agreement on UE capability from RAN4#108:

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| **Issue 1-2-1: Whether need to define a new or reuse the existing (*simultaneousReceptionDiffTypeD-r16*) capability for multi-panel simultaneous reception*** Agreement:
	+ Define a new UE capability [simultaneousReceptionFR2HST-r18] to indicate support of simultaneous multi-panel reception for Rel-18 FR2 PC6 UE
		- Details can be discussed in Rel-18 feature list discussion.
			* The conclusion from Rel-18 Multi-RX WI could be considered.
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* Proposals and Observations:
	+ **Proposal 1** (Ericsson): We lean towards Option2: add a new component to FR2 HST feature group in Rel-18.
	+ **Proposal 1** (Nokia): To support PC6 UE capability for simultaneous two-panel reception in HST Enhanced Rel-18 in the feature list, RAN4 needs either 1) to define a new dedicated feature group in Rel-18 or 2) to update existing Rel-17 feature group (22-1) in Rel-18 by adding a new component for simultaneous reception.
	+ **Proposal 1** (Samsung): RAN4 to introduce a new feature group 34-1 for FR2 HST with simultaneous DL reception with two different QCL TypeD RSs as optional with capability signaling to indicate the supported simultaneous reception with different QCL Type-D RSs in NR FR2 HST with:
		- Feature 22-1 and 16-2c as the prerequisite feature groups for the new 34-1
		- “Support of enhanced RF requirements”, “ Support of enhanced RRM measurement requirements, including the enhanced requirement of SSB-based Layer-1 measurement and the support of MRTD requirement for FR2-1 PC6 UEs with simultaneous DL reception with two different QCL TypeD RSs specified in TS38.133”, and “Support of enhanced demodulation processing” to support FR2-1 PC6 UEs with simultaneous DL reception with two different QCL TypeD RSs as specified in TS 38.133 as 34-1 feature group components
* Tentative agreements:
	+ RAN4 to define a new feature group for the support of simultaneous multi-panel reception for Rel-18 FR2 PC6 UE.
* Recommended WF
	+ Confirm tentative agreement during the meeting.

#### Issue 1-1-2: UE features for CA

* Background:
	+ RAN4#108 meeting agreements:

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| **Topic #2: Intra-band carrier aggregation (CA) scenario**Issue 2-1-1: Whether need to support separate CA and inter-frequency enhancements for Rel-18 FR2 HST* Agreements
	+ Introduce per-UE capability to indicate whether the UE is capable of supporting the enhanced RRM requirements for Connected and Idle mode inter-frequency measurements for FR2 HST

**Issue 2-1-1: Whether need to support separate CA and inter-frequency enhancements for Rel-18 FR2 HST (UE capability)*** Agreement:
	+ A single per-UE capability is introduced for FR2 HST CA and inter-frequency measurement enhancement:
		- [measurementEnhancementCAInterFreqFR2-r18] indicates whether the FR2 PC6 UE supports the enhanced RRM requirements for carrier aggregation as specified in TS 38.133 and the UE supports the enhanced RRM requirements for inter-frequency measurements in connected and idle mode as specified in TS 38.133.
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* Proposals and Observations:
	+ **Proposal 2** (Ericsson): We have concern on early measurement reporting, the applicability of early measurement shall be checked in advance.
	+ **Proposal 3** (Samsung): It is necessary to distinguish UE feature and UE capabilities for inter-frequency idle mode and connected mode.
	+ **Proposal 4** (Samsung): RAN4 to introduce a new feature group 34-2 for FR2 HST CA as optional with capability signaling to indicate the supported CA and inter-frequency measurement in connected mode for FR2 HST enhancement with:
		- Feature 22-1 as the prerequisite feature groups for the new 34-2
		- “Support of the enhanced RRM for requirement CA in connected mode to support FR2 high speed up to 350 km/h, as specified in TS 38.133” and “Support of the enhanced RRM for inter-frequency in connected mode to support FR2 high speed up to 350 km/h, as specified in TS 38.133” as 34-2 feature group components.
	+ **Proposal 5** (Samsung): RAN4 to indicate the support of FR2 HST idle/inactive mode inter-frequency measurement enhancements is an optional UE feature without capability signaling.
	+ **Proposal 6** (Samsung): There is no need to separate capabilities for idle/inactive measurement reporting in FR2 HST CA.
	+ Observation 4 (Nokia): Rel. 17 specified the HST FR1 CA related capabilities as three separate capabilities. Separate feature definition for idle mode enhancements is mainly related to this feature being an optional feature without capability signaling as this feature is expected to work in idle mode.
	+ **Proposal 3** (Nokia): Define the support for RRM requirements and inter-frequency measurements requirements for Connected and Idle mode as separate features.
	+ Observation 5 (Nokia): The carrier aggregation related benefit of inter-frequency measurements in idle mode is the early CA setup that enables fast increased throughput, using the idle/inactive measurement enhancement.
	+ Observation 6 (Nokia): Cell re-selection is a procedure supported by all the UEs and is not related to CA directly, whereas EMR support requires NW configuration and additional UE capability.
	+ **Proposal 4** (Nokia): Indicate the support for inter-frequency measurements requirements for idle mode measurement enhancement for early measurement reporting in idle and Inactive mode as a separate capability.
* Candidate options / tentative agreements:
	+ For PC6 UE inter-frequency enhancements and CA, RAN4 to define two new feature groups and capabilities in IDLE mode and in CONNECTED mode.
	+ Introduction of a new separate feature for inter-frequency measurements requirements for Idle mode measurement enhancement for early measurement reporting in Idle and Inactive mode:
		- Option 1 [Nokia]: Define measurement enhancement for early measurement reporting in Idle and Inactive mode as a separate capability/feature.
		- Option 2 [Samsung, Ericsson]: There is no need to separate capabilities for idle/inactive measurement reporting in FR2 HST CA
* Recommended WF
	+ Confirms the tentative agreement and discuss the options.

#### Issue 1-1-3: UE features for enhanced MAC CE

* Background:
* Proposals and Observations:
	+ **Proposal 7** (Samsung): RAN4 to introduce a new feature group 34-4 for FR2 HST enhanced UL timing adjustment as optional with capability signaling to indicate the supported enhanced one shot large UL timing adjustment with:
		- Feature 22-2 Support of one shot large UL timing adjustment as the prerequisite feature groups for the new 34-4
		- “Support of one shot large UL timing adjustment with 1 bit MAC-CE based cross-RRH indication” and “Support of TCI state switching delay measurement with 1 bit MAC-CE based cross-RRH indication” as 34-4 feature group components.
	+ **Proposal 1** (Ericsson): We slightly prefer Option 2. ‘The UE capability [highSpeedTCISwitchEnhMAC-CE-FR2-r18] to support of Rel-18 enhanced MAC-CE indication may be introduced as a new feature group: optional with capability signalling and with 22-1 Support of FR2 HST as a prerequisite.’
	+ Observation 3 (Nokia): One shot large UL timing adjustment for FR2 Power Class 6 UE and MAC-CE based TCI state switch delay in HST FR2 scenarios are enhanced in Rel-18 if the UE indicates to support [highSpeedTCISwitchEnhMAC-CE-FR2-r18] and [R18 enhanced MAC-CE indication] is indicated. Hence, [highSpeedTCISwitchEnhMAC-CE-FR2-r18] UE capability should not depend on the Support of one shot large UL timing adjustment only.
	+ **Proposal 4** (Nokia): Extend the existing 22-1 feature group (Support of FR2 HST operation) with the component corresponding to the support of R18 enhanced MAC-CE indication.
	+ **Proposal 5** (Nokia): The UE capability [highSpeedTCISwitchEnhMAC-CE-FR2-r18] to support of R18 enhanced MAC-CE indication may be introduced as a new feature group: optional with capability signalling and with 22-1 Support of FR2 HST as a prerequisite.
* Candidate options / tentative agreements:
	+ Define a new feature group for:
		- Option 1-a [Ericsson, Nokia]: The UE capability [highSpeedTCISwitchEnhMAC-CE-FR2-r18] to support of Rel-18 enhanced MAC-CE indication.
		- Option 1-b [Samsung, Intel]: Support of enhanced UL timing adjustment.
	+ Whether feature group depends on Rel-17 Feature group 22-2 “Support of one shot large UL timing adjustment”:
		- Option 2-a [Samsung, Ericsson, Intel]: Yes
		- Option 2-b [Nokia]: No
* Recommended WF
	+ Further discuss the candidate options during the meeting.

#### Issue 1-1-4: Summary of UE HST FR2 enhanced RRM UE features

* Background
	+ This issue collects the outcomes of all previous issues in this sub-topic.
* Candidate options / tentative agreements:

Rel-18 NR UE features for NR\_HST\_FR2\_enh WI

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| **Features** | **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 supported 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** |
| 34. NR\_HST\_FR2\_enh | [34-1] | Support of FR2 HST with multi-panel simultaneous reception operation | [x. Support of enhanced RRM requirements for FR2 PC6 UE with two panel simultaneous reception as specified in TS 38.133.] | 22-1 | Yes | N/A | UE does not meet FR2 high speed train scenario with two panel simultaneous reception | Per Band | No | FR2-1 only | N/A | [Component candidate value: true/false] | Optional with capability signalling |
| 34. NR\_HST\_FR2\_enh | [34-2] | [Enhanced RRM requirements for CA and inter-frequency measurements for HST FR2] | [Support of the enhanced RRM requirements for CA and inter-frequency measurements for HST FR2 PC6 UE in CONNCTED mode as specified in TS 38.133] | 22-1 | Yes | N/A | UE does not support enhanced RRM requirements for CA and/or inter-frequency measurements | [Per Band] or [Per UE] | No | FR2-1 only | N/A | [Component 1 candidate value: true/false] | Optional with capability signalling |
| 34. NR\_HST\_FR2\_enh | [34-3] | Enhanced inter-frequency measurement in IDLE and INACTIVE mode [for FR2 HST cell re-selection] | [Support of enhanced inter-frequency RRM measurement requirements in IDLE and INACTIVE mode for FR2 HST PC6 UE as specified in TS 38.133.] | [No] or [22-1/PC6] | No | N/A | UE does not support enhanced IDLE and/or INACTIVE mode FR2 HST UE mobility | [NA] or [Per UE] | No | FR2-1 only | N/A |  | Optional without capability signalling |
| [34. NR\_HST\_FR2\_enh] | [34-4] | [Enhanced RRM requirements for inter-frequency measurement in IDLE and INACTVE mode for FR2 HST IDLE measurement reporting] | [Support of the enhanced RRM requirements for inter-frequency measurement for early measurement reporting in idle and Inactive mode to support FR2 high speed as specified in TS 38.133] | [Rel-17 22-1 and Rel-16 feature 18-7] | [No] | [N/A] | [The performance of RRM for inter-frequency measurement in idle and Inactive mode for FR2 HST cannot be] | [Per UE] | No | FR2-1 only | N/A |  | [Optional with capability signalling] |
| 34. NR\_HST\_FR2\_enh | [34-5] | [Support of enhanced UL timing adjustment] or [Support of enhanced MAC CE TCI state switch indication for HST FR2] | [1. Support of enhanced large one-shot UL transmit timing adjustment as specified in TS 38.1332. Support of enhanced TCI state switching delay requirement as specified in TS 38.133] | [22-2] or [22-1] | Yes | N/A | [UE does not support enhanced UL timing adjustment] or [UE follow legacy Rel-17 RRM requirement] | Per Band | No | FR2-1 only | N/A | [Component 1 candidate value: true/false] | Optional with capability signalling |

* Recommended WF
	+ Discuss further during the meeting taking into account the agreements for the previous issues in the WF.

### Sub-topic 1-2: UL timing adjustment requirements

*Sub-topic description:*

In this sub-topic the proposals related to the maintenance of UL transmit timing adjustment and enhanced MAC CE design in HST FR2 enhanced.

LS reply to RAN2 [[R4-2314299](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_108/Docs/R4-2314299.zip)], RAN4 has described the following UE behaviour based on the enhanced MAC CE indication:

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| RAN4 sees a need to define enhanced MAC CE indication in HST FR2 deployments and corresponding [*highSpeedTCISwitchEnhMAC-CE-FR2-r18*] UE capability:* If MAC-CE bit indicates “1” then for the TCI state switch, UE may expect that there is a large timing difference between DL signals from two non-collocated RRHs.
* If MAC-CE bit indicates “0” then for the TCI state switch, UE may expect that the timing difference between DL signals from two RRHs or from the same RRH is smaller than a quarter of CP.

...* In HST FR2 scenario, when *highSpeedMeasFlagFR2-r17* is configured the following HST PC 6 UE behavior is expected upon the reception of enhanced MAC CE:
1. **MAC-CE indicates “1”**:
	1. Rel-17 TCI state switching delay requirements in HST FR2 scenarios from TS 38.133, Clause 8.10.3A are followed without changes.
	2. When *highSpeedLargeOneStepUL-TimingFR2-r17* is enabled for HST PC 6 UE supporting [*largeOneStepUL-timingFR2-r17*] capability, UE shall apply the one shot large timing adjustment specified in Clause 7.1.2.3 in TS 38.133 on the first UL transmission after TCI state switch without checking the DL timing difference threshold.
2. **MAC-CE indicates “0”:**
	1. UE follows the Rel-15 TCI state switching requirements as described in TS 38.133 Clause 8.10.3
	2. Gradual timing adjustment requirements in Clause 7.1.2.1 in TS 38.133 apply to the first UL transmission after TCI state switch, i.e., one shot large UL timing adjustment is not applied.
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In it’s latest reply LS RAN2 [[R2-2311615](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_123bis/Docs/R2-2311615.zip)] notices that it seems to them that the case when “0” is signalled is very close to legacy behaviour. Hence, UE behaviour and signalling can be potentially simplified:

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| FFS Introduce new MAC CE that has the same payload as “TCI State Indication for UE-specific PDCCH MAC CE” with eLCID. Pending RAN4 clarificationsIn the RAN2 discussion there was no clear understanding regarding answer 3 in the LS why we need a new MAC CE indicating separately “1” and “0” as it looked like case “0” seemed to be similar to behavior of UE in case of receiving the legacy MAC CE (i.e. MAC CE intended for indicating target TCI state for PDCCH in 6.1.3.15) with a possible difference being that UE does not check downlink timing difference. But it caused confusion in RAN2 because companies think NW can send legacy MAC CE to the UE when NW thinks the timing difference is not large to address the case ”0” in RAN4’s LS”, as UE will not apply large one shot UL timing adjustment. If this is the case then it would simplify RAN2 work as we could just introduce new MAC CE with the same contents of the legacy MAC CE with just a new (e)LCID (i.e.to correspond to MAC CE with “1” as described in the LS R4-2314299) and avoid designing a new MAC CE with an extra octet indicating value “1” or value “0” explicitly and thus causing extra overhead.**2. Actions:****To RAN4 group.****ACTION:** RAN2 respectfully asks RAN4 to clarify if it would be possible to design new MAC CE to only correspond to case “1” as presented in R4-2314299 |

#### Issue 1-2-1: New MAC CE corresponds to case “1” or case “0”?

* Proposals and Observations:
	+ Observation 1 (Nokia): RAN2 in the reply LS wrongly assumes that “case “0” seemed to be similar to behaviour of UE in case of receiving the legacy MAC CE” and that “NW can send legacy MAC CE to the UE when NW thinks the timing difference is not large”. However, in Rel-17, legacy “TCI State Indication for UE-specific PDCCH MAC CE” is already used in HST FR2 scenario for PC6 UEs when there is large timing difference between DL signals from two non-collocated RRHs.
	+ **Proposal 1** (Nokia): PC6 UE behaviour in Rel-18 shall stay the same as it was in Rel-17 when legacy MAC CE TCI state switch indication for PDCCH is received (i.e., as described in Rel-17 Clause 7.1.2.3 and 8.10.3A in TS 38.133).
	+ Observation 2 (Nokia): The case when MAC-CE indicates “0” contains more significant changes to the legacy Rel-17 PC6 UE behaviour in comparison to the case “1” because in Rel-17 the possibility of large propagation delay difference was already considered, and DL time deference needs to be evaluated in any case. Moreover, in Case “1” TCI state switch delay does not need to be changed from Rel-17 either.
	+ **Proposal 2** (Nokia): If it is agreed to keep a single case for the new MAC CE indication with the same payload as “TCI State Indication for UE-specific PDCCH MAC CE” with eLCID, then only Case “0” shall be used.
	+ Observation 1 (Samsung): It is RAN2 understanding that if “0” does not indicate any extra new information except the legacy behavior, a new 1 bit (e)LCID can totally correspond to the intention of MAC CE with “1”, and there is no need to design a new MAC CE with an extra octet indicating value “1” or value “0”.
	+ **Proposal 1** (Samsung): The extra NW information, i.e., the upcoming TCI state switching information, is not necessary to be included in the 1 bit MAC-CE indication signalling.
	+ **Proposal 2** (Samsung): “0” in our RAN4 1 bit MAC-CE indication only indicate the intention of “legacy” requirements.
	+ **Proposal 3** (Ericsson): Accept RAN2’s proposal in R2-2311619, i.e., design new MAC CE to only correspond to case “1” as presented in R4-2314299, otherwise the UE shall check downlink timing difference.
* Candidate options / tentative agreements:
	+ Option 1 [Nokia]: New MAC CE shall correspond to case “0”.
	+ Option 1 [Samsung, Ericsson]: New MAC CE shall correspond to case “1”.
* Recommended WF
	+ Discuss during the meeting and reflect in TS and Reply LS.

#### Issue 1-2-2: Would be possible to design new MAC CE to only correspond to a single case?

* Proposals and Observations:
	+ Proposal 2 (Nokia): If it is agreed to keep a single case for the new MAC CE indication with the same payload as “TCI State Indication for UE-specific PDCCH MAC CE” with eLCID, then only Case “0” shall be used.
	+ **Proposal 1** (Samsung): RAN4 provide the following reply to question raised in RAN2 LS:
		- It would be possible to design a new MAC CE to only correspond to case “1” as presented in R4-2314299
			* It is possible to combine a new 1 bit (e)LCID with same contents of the legacy MAC CE (legacy MAC CE format) to design the MAC-CE based indication for cross-RRH TCI state
	+ **Proposal 3** (Ericsson): Accept RAN2’s proposal in R2-2311619, i.e., design new MAC CE to only correspond to case “1” as presented in R4-2314299, otherwise the UE shall check downlink timing difference.
* Tentative agreements:
	+ Yes, it is possible to design the new MAC CE indication with the same payload as “TCI State Indication for UE-specific PDCCH MAC CE” with eLCID.
* Recommended WF
	+ Discuss tentative agreement based on the outcomes of the previous issue.

#### Issue 1-2-3: A need for Reply LS to RAN2

* Proposals and Observations:
	+ **Proposal 3** (Nokia): RAN4 to prepare the LS reply to RAN2 based on the draft from the appendix of this paper.
* Recommended WF
	+ RAN4 need to reply to RAN2.

#### Issue 1-2-4: Timing adjustment and UL spatial relation switch

* Background

WF from RAN4#108bis:

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| **Issue 1-3-2: Timing adjustment and UL spatial relation switch****Way forward:*** Further check whether and how UL spatial relation switch shall be executed when corresponding DL TCI state is switched in Rel-18 bi-directional deployments with multi-panel reception when large one shot UL timing adjustment is used (other conditions FFS)
	+ Option 1: UL spatial relation switch shall always be executed strictly when the corresponding DL TCI state switches
	+ Other options are not precluded
 |

* Proposals and Observations:
	+ **Proposal 2** (Ericsson): We’re open to Option 1 or other solutions which apply the mechanism to DL TCI state switch here for UL spatial relation switch.
	+ **Proposal 1** (Huawei): There is no need to define additional UL transmit timing adjustment at UL spatial relation switch, and the existing timing adjustment requirements can be applied.
	+ Observation 1: For the multi-panel reception in the tunnel scenario, if the UL is transmitted toward the RRH having the beam orientation opposite to the train travelling direction, then the UL will be disrupted in the case of beam/link failure next to the RRH.
	+ Observation 2: If UL spatial relation has to be switch always together with TCI state switch (regardless of the UE panel) a performance degradation in UL is observed because UL cannot be configured for transmission towards the best RRH.
	+ Observation 3: Decoupling of DL TCI state and UL Spatial relation switches does not completely resolve the issue because independent UL Spatial relation switch might be also associated with a large change in UL Tx timing.
	+ **Proposal 1** (Nokia): If UL TX timing adjustment at UL spatial relation switch is agreed in Rel-18 for HST FR2 scenario, RAN4 to shall agree that UL spatial relation switch shall always be executed strictly with the corresponding DL TCI state switches and performance degradation in UL is acceptable.
	+ **Proposal 2** (Nokia): RAN4 to consider introducing one shot UL timing adjustment procedure at UL Spatial relation switch in HST FR2 deployments with simultaneous two panel reception.
* Candidate options / tentative agreements:
	+ Option 1 [Nokia, Ericsson]: UL spatial relation switch shall always be executed strictly when the corresponding DL TCI state switches
	+ Option2 [Nokia]: Introducing one shot UL timing adjustment procedure at UL Spatial relation switch in HST FR2 deployments with simultaneous two panel reception
	+ Option 3 [Huawei]: There is no need to define additional UL transmit timing adjustment at UL spatial relation switch, and the existing timing adjustment requirements can be applied
* Recommended WF
	+ Discuss options during the meeting.

### Sub-topic 1-3: Intra-band CA

*Sub-topic description:*

In this sub-topic the proposals related to the maintenance of CA operation in HST FR2 enhanced.

#### Issue 1-3-1: SCell activation delay requirement

* Background
	+ WF from RAN4#108bis:

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| **Issue 1-2-1: SCell activation delay requirement****Way forward:**Further discuss additional condition/capability needed for SCell activation delay for PC6 UE:* Option 1: The SCell activation delay requirement does not need to be enhanced for Rel. 18 PC6 UEs by default, i.e., *SCellwithoutSSB* capability can be reused to indicate the support for “3 ms” SCell activation delay (revert the CR from RAN4#108)
* Option 2: Keep the Core requirement if a test for the 3ms activation delay in the HST FR2 Rel-18 performance part is introduced
* Option 3: Keep the Core requirements and FFS for test cases
 |

* + Support of SCell without SS/PBCH block feature (*SCellwithoutSSB*) is mandatory with capability signalling
	+ FR1 SCell activation test (A.6.5.3.2) verified that
		- The test requirements defined in clause A.6.5.3.1.2 shall apply to this test case, except Tactivation\_time will be replaced with the value **TFirstSSB\_MAX + Trs + 5ms**.
	+ FR2 A.7.5.3.1.2 Test Requirements:
		- The test requirements defined in clause A.6.5.3.1.2 shall apply to this test case, except Tactivation\_time will be replaced with the value **TFirstSSB + 5ms** as defined in clause 8.3.
* Proposals and Observations:
	+ **Proposal 1** (Ericsson): Keep Core requirement. No test case for the 3ms activation delay in the HST FR2 Rel-18 performance part is needed.
	+ Observation 1: The SSB-less and SSB-based SCell activation performance are almost the same.
	+ Observation 2: For PC6 UE, supporting scellWithoutSSB can be a default capability, and it has NO need to perform additional SSB based fine synchronization even if SSB is configured on the being activated SCell.
	+ Observation 3: No need to introduce new capability to support 3ms SCell activation for PC6 UE.
	+ **Proposal** (Huawei): No additional capability and condition are needed for PC6 supporting 3ms SCell activation in FR2 intra-band HST scenario.
	+ **Proposal 2** (Samsung): For SCell activation delay for PC6 UE, keep the core requirements but do not define any test cases for such requirement.
	+ Observation 1 (Nokia): Technical benefit of specifying the new requirement with a shorter activation time is “2 ms + TFirstSSB” faster activation.
	+ Observation 2 (Nokia): No test cases were defined for “3 ms” SCell activation delay. SCellwithouSSB is mandatory with capability signalling for intra-band CA, i.e., shall be supported by default but may not be supported yet by the UEs.
	+ Observation 3 (Nokia): Enhanced requirement for HST FR2 is not justified enough when the existing requirement with the “SCellwithoutSSB” capability can be re-used.
	+ **Proposal 1** (Nokia): The SCell activation delay requirement does not need to be enhanced for Rel. 18 PC6 UEs by default, i.e., SCellwithoutSSB can still be used as an additional conditions for shorter activation delay.
	+ **Proposal 2** (Nokia): A new Activation delay test shall be introduced if the requirement does not have SCellwithoutSSB as a condition.
* Candidate options / tentative agreements:
	+ Option 1 [Nokia]: The SCell activation delay requirement does not need to be enhanced for Rel. 18 PC6 UEs by default, i.e., SCellwithoutSSB capability can be reused to indicate the support for “3 ms” SCell activation delay (revert the CR from RAN4#108)
	+ Option 2 [Nokia]: Keep the Core requirement if a test for the 3ms activation delay in the HST FR2 Rel-18 performance part is introduced.
	+ Option 3 [Huawei]: No additional capability and condition are needed, Keep the current Core requirement
	+ Option 4 [Samsung, Ericsson]: Keep Core requirement. No test case for the 3ms activation delay in the HST FR2 Rel-18 performance part is needed.
* Recommended WF
	+ Discuss options during the meeting.