**3GPP TSG-RAN WG4 Meeting # 111 R4-24xxxxxxx**

**Fukuoka, JP, May 20 – May 24, 2024**

**Title:** WF on NR mobility enhancements (part 1)

**Agenda Item:** 7.14.3

**Source:** MediaTek Inc.

**Document for:** Approval

# 0 Notes:

In this document,

* < **Agreement** > represents the decisions made by in this meeting
* < **Way forward** > represents the next step in later meetings
	+ “FFS” does not mean RAN4 will make a down-selection for the item. More other options can be proposed.
* < **Tentative Agreement** > will be changed to < **Agreement** > if no comments are received.

# 1 Topic #1: LTM - General aspects and scenarios

## Sub-topic 1-1 PDCCH-order RACH on neighbor cell

**Issue 1-1-1: The value of TSSB is if the condition of TSSB equal to zero is not met in PDCCH ordered RACH delay requirements**

**<Tentative agreement>:**

* + In PDCCH ordered RACH delay, when additional time for T/F tracking is needed, TSSB is:
		- * TSSB is the time to first SSB transmission after PDCCH-order RACH command is decoded by the UE when SSB is within active BWP + 2ms

*Ad hoc agreement*

**<Agreement>:** When SSB is outside active BWP, follow the agreement in Issue 1-3-2.

**Issue 1-1-2: Conditions for TSSB= 0 in PDCCH ordered RACH delay requirement**

Merged to Issue 1-3-6.

**Issue 1-1-3: How to capture the case with no UL Tx timing accuracy requirements in spec**

*For information*

|  |
| --- |
| ***RAN4#109*****Issue 1-2-1-2: The value of additional time for DL synchronization when needed in the delay requirements for PDCCH ordered RACH before cell switch command****<Agreement>:** * For FR2, one Tssb delay is always assumed before UE transmit PDCCH-ordered RACH.
* For FR1, when TCI state associated the PDCCH-order RACH has not been activated,
	+ one Tssb delay is always assumed before UE transmit PDCCH-ordered RACH.
* For FR1, when TCI state associated the PDCCH-order RACH is activated,
	+ If L1-RSRP measurement delay is less than or equal to 160ms, Tssb is not needed. UE is required to meet the UL Tx timing accuracy requirements
	+ If L1-RSRP measurement delay is more than 160ms, UE is allowed to transmit PDCCH-ordered RACH with or without one Tssb delay. No UE UL Tx timing accuracyrequirement will be defined.
 |

**<Way Forward >:**

* + Discuss in the corresponding CR directly.

**Issue 1-1-4: Applicability rule of PDCCH-order RACH delay**

**<Way Forward >:**

* + Discuss in the corresponding CR directly.

## 1.2 Sub-topic 1-2 UE based TA measurement

**Issue 1-2-1: Whether and how to define timing requirements for UE based TA measurement**

 *Online agreement*

< **Agreement**>: Agreement on Core requirements for UE based TA measurement

* + Not to define dedicated requirements for UE based TA measurement in R18.
	+ It is RAN4 common understanding that the feature is supported in RAN1/2 specification.

## 1.3 Sub-topic 1-3 Early Candidate cell’s TCI state activation

**Issue 1-3-1: Whether to consider early TCI state activation for multiple cells at the same time**

* Proposals
	+ Option 1 (Huawei, vivo, Nokia, MTK):
		- Early TCI state activation delay requirements to be defined for one or more TCI states for a single candidate cell, because one MAC-CE activates TCI states only for a single candidate cell.
	+ Option 2 (Ericsson, QC):
		- If all the target LTM TCI states in the active TCI state list are known, if the UE receives TCI state activation command at slot n, UE shall have completed the LTM TCI state list update in slot n + THARQ +$3N\_{slot}^{subframe,µ}$ + TOk\*(Tfirst-SSB\_List + TSSB-proc) / *NR slot length*.
		- If any of the target TCI states in the active TCI state list are unknown, if the UE receives TCI state activation command at slot n, UE shall have completed the LTM TCI state list update in slot n+ THARQ +$3N\_{slot}^{subframe,µ}$ + (TL1-RSRP\_list +TOuk\*(Tfirst-SSB\_List+ TSSB-proc)) / *NR slot length*.
		- In the TCI state activation requirements for LTM candidate cells, T L1-RSRP = 0 for FR1
		- In the TCI state activation requirements for LTM candidate cells, Tfirst-SSB\_List is given by
			* For FR1, Tfirst-SSB\_List = max (Tfirst-SSB\_LTM1, Tfirst-SSB\_LTM2, .. , Tfirst-SSB\_LTMn).
			* For FR2,
				+ Tfirst-SSB\_List = Tfirst-SSB\_LTM1 + Tfirst-SSB\_LTM2 + ... +Tfirst-SSB\_LTMn, if the time to first SSB associated to LTM candidate TCI states are overlapped in FR2.
				+ Tfirst-SSB\_List = max (Tfirst-SSB\_LTM1, Tfirst-SSB\_LTM2, .. , Tfirst-SSB\_LTMn.) if the time to first SSB associated to LTM candidate TCI states are not overlapped.
			* Where, the Tfirst-SSB\_LTMn is the SSB periodicity of LTM candidate cell n.

< **Tentative Agreement** >

* + Early TCI state activation delay requirements to be defined for one or more TCI states for a single candidate cell, because one MAC-CE activates TCI states only for a single candidate cell.

**Issue 1-3-2: The definition of Tfirst-SSB in early candidate cell’s TCI state activation delay for inter-frequency with gap for known TCI state case**

*Ad hoc agreement*

< **Agreement**>:

* + In early candidate cell’s TCI state activation delay for known TCI state case: Tfirst-SSB is the time to the first SSB occasion overlapped with MGL after slot n + THARQ +$3N\_{slot}^{subframe,µ}$ + [2ms] if the SSB needs to be measured with MG.
		- FFS: this is only applicable to UE supporting inter-frequency L1 measurement with MG.
	+ Same agreement applies to the definition of Tfirst-SSB in PDCCH order RACH delay requirement.

**Issue 1-3-3: Whether and how to support unknown TCI state in FR2**

**<Way Forward >:** Further discuss the following options:

* + Option 1 (vivo):
		- RAN4 further discuss whether the scenario below is an important scenario in FR2, and whether RRM requirements need to be specified.
			* Based on the agreed big CR, and the requirement applicability rules for L1-RSRP measurements, LTM TCI activation delay requirements are not applicable to the case when activated TCI state(s) of one candidate cell already exist, but gNB activates one more unknown TCI state from another candidate cell on top of activated TCI state(s) from the existing candidate cell.
	+ Option 2 (Huawei, MTK):
		- Not to define requirements of SSB based TCI state activation delay for FR2 unknown TCI state case.
	+ Option 3 (Nokia):
		- When UE is performing and reporting L1 measurements for LTM candidate cells, unknown TCI state activation delay may follow the legacy requirement.
		- When UE is not performing L1 measurements and LTM decision is based on L3 measurements (if supported), L1-RSRP measurement period in legacy unknown TCI state activation delay can be replaced with L3-RSRP measurement period.
	+ Option 4 (Ericsson, QC): In the TCI state activation requirements for LTM candidate cells, for FR2, T L1-RSRP is the time for Rx beam refinement in FR2, defined as
		- TL1-RSPR\_Measurement\_Period\_SSB for SSB as specified in clause 9.14 and 9.15,
		- with the assumption of M=1
		- with TReport = 0
		- NNeighbor\_Cell is the number of neighbour cells that are to be activated with TCI states

**Issue 1-3-4: Conditions to support unknown TCI state in FR1 for early TCI state activation**

< **Tentative Agreement**>:

* + UE has reported beam-level L3 measurement result of the associated SSB of the TCI state within [1280ms or 5 seconds] before the LTM TCI state activation command.
	+ SNR of the associated SSB is above -3dB.

**Issue 1-3-5: Whether to consider early UL TCI state activation**

**<Way Forward >:** Further discuss the following option:

* + Option 1 (vivo):
		- Not to consider uplink TCI activation before cell switch, i.e. both uplink TCI activation delay including known state definition, and additional time for PL-RS measurement including known state definition and maintained state definition, are not specified for the time gap of TCI pre-sync before cell switch.

**Issue 1-3-6: cell switch delay and PDCCH order RACH delay requirements without L1 measurement**

*Ad hoc agreement*

< **Agreement**>:

* In cell switch delay requirement:
	+ In FR1, for UE not supporting/configured with L1 measurement, one SSB occasion is needed from RAN4 requirement point of view for T/F fine tracking, if
		- the time gap between completion of TCI activation and cell switch command is larger than [160ms], or
		- the time gap between early RACH transmission and cell switch command is larger than [160ms].
* In PDCCH order RACH delay requirement:
	+ In FR1, for UE not supporting/configured with L1 measurement, one SSB occasion is needed from RAN4 requirement point of view.

**Issue 1-3-7: Whether to consider TRS as QCL source in early candidate cell’s TCI state activation**

*As far as moderator know, supporting TRS as QCL source for early TCI state activation was a late conclusion in RAN1. RAN4 didn’t discuss the requirements for TRS as QCL source for early TCI state activation.*

* Proposals
	+ Option 1 (Nokia):
		- Add TRS as a possible QCL source for T/F tracking in RAN4 TCI state activation requirements.

**<Way Forward >:** Collet more views from different companies.

**Issue 1-3-8: Others**

* Proposals
	+ Proposal 1 (Nokia):
		- Extend the agreement “When the target cell is a current serving cell (role switch) and the target TCI state in LTM cell switch command or SSB index indicated in PDCCH order is already on the active TCI state list for that serving cell or on the LTM candidate cell active TCI state list, consider the target TCI state activated.” to cover also the time gap between TCI state activation MAC-CE and LTM cell switch command.

**<Way Forward >:** Discuss in the CR directly.

# Topic #2: LTM - L1-RSRP measurement requirements

## 2.1 Sub-topic 2-1 Scenarios

**Issue 2-1-1: whether to consider** **L1-RSRP measurement on deactivated SCell**

*Online agreement*

< **Agreement**>:

* + In Rel-18, RAN4 will not define the requirement for L1-RSRP measurement on deactivated SCell.
	+ It is up to UE on how to perform the measurement if the L1-RSRP measurement on deactivated SCell is supported based on RAN1/2 design.

**Issue 2-1-2: L1-RSRP measurement on intra-f neighbor cell of deactivated SCC**

*Online agreement*

< **Agreement**>:

* + Apply the same agreement in Issue 2-1-1.

## 2.2 Sub-topic 2-2 Measurement period

**Issue 2-2-1: Measurement period of serving cell L1-RSRP measurement**

**<Way Forward >:** Further discuss the following options:

* + Option 1 (Apple):
		- introduce NLayer in serving cell L1 RSRP measurement requirement and clarify that it is for UE capable of RTD>CP configured with L1 RSRP measurement on neighbour cell.
	+ Option 2 (OPPO):
		- Consider to revisit the agreements for L1 RSRP measurement on neighbour cell, e.g., either follow the logic of serving cell L1-RSRP measurement or L3 intra-frequency measurement.
	+ Option 3 (Ericsson, QC):
		- RAN4 not to modify the serving cell measurement period by scaling it with NLayer for UE supporting RTD > CP.

## 2.4 Sub-topic 2-4 Others

**Issue 2-4-1: L1 report for unmeasured candidate cells**

**<Way Forward >:** Further discuss the following options:

* + Option 1 (vivo):
		- In L1-RSRP measurement report, for unmeasured candidate cells, UE sends invalid L1-RSRP in PUCCH if needed, i.e. the reported value corresponds to one of the invalid codepoints for L1-RSRP in Table 10.1.6.1-1 or DIFFRSRP\_15 in Table 10.1.6.1-2.
		- In this case, the SSB or the cell it reflects remains unknown to the UE.
	+ Option 2 (CTC):
		- In L1-RSRP measurement report, for unmeasured candidate cells, UE reports measured quantity value corresponding to any of the invalid codepoints in Table 10.1.6.1-1.
	+ Option 3 (Nokia): RAN4 to send LS to RAN1
		- Question: From RAN1 point of view, is it acceptable for the UE to report invalid values (from table 10.1.6.1-1 of TS 38.133) or value DIFFRSRP\_15 (from table 10.1.6.1-2 of TS 38.133) for LTM candidate cells that are not measured by the UE? At least the following should be considered:
			* When none of the candidate cells are measured within the given periodicity, UE reports a 7 bit “Not valid” value.
			* DIFFRSRP\_15 is reported when at least one LTM candidate cell was measured and at least one configured candidate cell was unmeasured.
			* The reported values for unmeasured cells do not meet any measurement requirements as they are unmeasured.
	+ Option 4 (Ericsson, QC):
		- In L1-RSRP measurement report, for unmeasured candidate cells, UE reports DIFFRSRP\_15 in Table 10.1.6.1-2.

**Issue 2-4-2: Spec organization**

**<Way Forward >:** Further discuss the following option:

* + Option 1 (CATT, vivo):
		- Capture all LTM L1 measurement requirements, including serving cell L1 measurement requirements in 9.14.
		- vivo: The impact to legacy serving cell L1 measurement due to Rx beam sharing with neighbour cell LTM L1 measurement is captured by PL1\_sharing in 9.5.4.1

**Issue 2-4-4: Clarifications**

**<Way Forward >:** Further discuss the following option:

* + Proposal 1 (vivo):
		- Clarify the RTD for LTM L1 measurement as the Rx timing difference between cells configured by LTM-CSI-ResourceConfig-r18 on which UE is required to perform L1 measurements also for the intra-frequency L1 measurements.

# 3 Topic #3: LTM – Cell switch delay requirements

## 3.1 Sub-topic 3-1 Detail of cell switch delay requirements for Pcell/PSCell

#### 3.1.1 T/F fine tracking: TΔ and Tmargin

**Issue 3-1-1-1: T/F fine tracking when TRS as QCL source in cell switch delay**

**<Way Forward >:** Further discuss the following options:

* + Option 1 (MTK): UE is supposed to perform T/F tracking (if needed) based on SSB during cell switch delay in R18 LTM.
	+ Option 2 (Nokia): Add TRS as a possible QCL source for T/F tracking in RAN4 cell switch delay requirements.

**Issue 3-1-1-2: Conditions of Tfirst-RS =0 in cell switch delay**

Merged to Issue 1-3-6

#### 3.1.2 Extra time for PL-RS measurement

**Issue 3-1-2-1: Extra time for PL-RS measurement**

*Ad hoc agreement*

< **Agreement**>:

* + No additional PL-RS measurement time is needed, provided
		- Option 1: L3-RSRP or L1-RSRP on the SSB associated with PL-RS has been measured/reported
		- Option 2: Target PL-RS is maintained.

#### 3.1.3 Tinterruption

**Issue 3-1-3-1: Tinterruption** **of PSCell switch**

**<Tentative Agreement** >:

* + The interruption on MCG due to PSCell switch is the same as PSCell addition.

#### 3.1.4 Conditions of Early ASN.1 decoding and validity/compliance check

**Issue 3-1-4-1: Which cell(s) TLTM-RRC-processing = 0 apply to when candidate cells configured are more than UE capability?**

**<Way Forward >:** Further discuss the following options:

* + Option 1 (Apple):
		- NW is not expected to trigger TCI activation or RACH toward candidate cell unless cell switch is likely to happen soon.
		- TLTM\_RRC-processing in TS38.133 is zero only applicable to the cells with early TCI activation or early TA acquisition, provided the number of these cells doesn’t exceed UE capability regarding number of cells for early ASN.1 decoding.
	+ Option 2 (Huawei):
		- TLTM-RRC-processing = 0, if the UE supports [*earlyDecodingAndValidityCheck*] capability, and the maximum number of serving cell(s) and candidate cell(s) and the maximum number of *LTMCandidateConfigs* does not exceed [*number of candidate cells for early ASN.1 decoding and validity check*]. Early TCI state activation or PDCCH order RACH does not necessarily trigger early decoding and validity check.
	+ Option 3 (Nokia):
		- When TCI state activation MAC-CE or PDCCH order is sent for more cells than UE capability for fast processing, the cells for which the UE received TCI state activation MAC-CE or PDCCH order the most recently before cell switch command are the ones that are pre-processed
	+ Option 4 (MTK):
		- TLTM\_RRC-processing in TS38.133 is zero only applicable to the cells whose TCI state(s) are activated, if early TCI state activation on any candidate cell is triggered, and the number of cells to perform early RRC decoding and validity check does not exceed UE capability.
		- TLTM\_RRC-processing in TS38.133 is zero only applicable to the latest cell on which PDCCH-order RACH is triggered if NW doesn’t active TCI state of any candidate cell
	+ Option 5 (Ericsson, QC)
		- The ltm-CandidateConfig IEs associated with at least one active TCI state
		- The ltm-CandidateConfig IEs associated with previously performed PDCCH-order PRACH.
		- If the number of the ltm-CandidateConfig IEs associated with active TCI state and PDCCH-order PRACH transmission is larger than maxLTMCandidateConfig, the ltm-CandidateConfig IEs for fast RRC processing are chosen in reverse chronological order of Candidate Cell TCI States Activation MAC CE and PDCCH-order PRACH, i.e. maxLTMCandidateConfig ltm-CandidateConfig IEs with the most recently activated TCI states and PDCCH-order PRACH transmission.
		- The current serving cells and the cells inside the ltm-CandidateConfig, chosen by the above condition, across cell groups (i.e. MCG and SCG) is not larger than maxServingAndCandidteCells

**Issue 3-1-4-2: Condition on time gap between PDCCH-order and cell switch command for TLTM\_RRC-processing =0**

< **Tentative Agreement**>:

* + The time gap from the slot where the UE received the PDCCH triggering the PDCCH-order PRACH transmission to the slot where the UE received the LTM cell switch MAC CE is larger than NT,2+10ms, if the condition of ‘fast RRC processing’ is met by the PDCCH-order PRACH transmission.

*Moderator: NT,2 is the time given for PDCCH-order decoding in moderator’s understanding*

#### 3.1.5 TLTM-processing

**Issue 3-1-5-1: Value of TLTM-processing**

<**Way Forward** >: **Further discuss the following proposal**

* + In R18, if target SpCell is current SCell, TLTM-processing is 10 ms for intra-FR and 20ms for inter-FR.

## 3.4 Sub-topic 3-3 Known conditions

**Issue 3-3-1: known TCI state conditions**

*Online Agreement*

**< Agreement >**

* For FR1, the cell switch delay requirement is applicable for the case without L1 measurement and report, under certain conditions.
	+ Further discuss the how the requirement applies together with the condition.

< **Agreement**>:

* In FR2: the RAN4 Rel-18 related LTM requirements are not applicable if L1 measurement of LTM candidate cell is not supported or configured.

<**Way Forward** >: Further discuss the following options in FR1:

* + Option 1: change known TCI state conditions to make cell switch delay requirements applicable to the case without L1 measurement and report
	+ Option 2: Allow cell switch delay requirements applicable to unknown TCI state case with conditions.
	+ Regarding the conditions, further discuss the following options when SNR of the TCI state≥ -3dB
		- * Condition 1: TCI state has been activated and
				+ Condition 1A: the TCI state activation command was received not more than 1280 ms before the cell switch command
				+ Condition 1B: Beam-level L3 measurement results have been reported in 1280 ms
				+ Condition 1C: The RS associated to the target TCI state is available at least every 1280 ms after TCI state activation command
			* Condition 2: UE has reported L3-RSRP measurements for the SSB associated to the target TCI state in [1280]ms before the cell switch command

<**Way Forward** >: Further discuss the following options in FR2:

* + - Condition 3: TCI state has been activated and
			* Condition 3A: the TCI state activation command was received not more than 1280 ms before the cell switch command
			* Condition 3B: the TCI state activation command was received not more than 160 ms before the cell switch command
			* Condition 3C: The RS associated to the target TCI state is available at least every 1280 ms after TCI state activation command
			* Condition 3D:
				+ Beam-level L3 measurement results have been reported in 1280ms
				+ L1-RSRP measurement period is no larger than 1280ms in FR2
		- Condition 4: UE has reported L3-RSRP measurements for the SSB associated to the target TCI state in [1280]ms before the cell switch command

# 4. Topic #4: LTM – RAN2 LS

Discuss the wording in the reply LS.

*Online agreement*

< **Agreement**>:

* For FR1, the cell switch delay requirement is applicable for the case without L1 measurement and report, under certain conditions.
	+ Further discuss the how the requirement applies together with the condition.

< **Agreement**>:

* In FR2: the RAN4 Rel-18 related LTM requirements are not applicable if L1 measurement of LTM candidate cell is not supported or configured.

# 5. Topic #5: LTM – UE feature

### 5.2.1 Sub-topic 5-1

**Issue 5-1-2: Optimization on consequence of not supporting some features**

**<Way Forward >:** Further discuss the following proposals:

* + Proposal 1 (vivo): Adopt the optimization on consequence of not supporting 39-1 as following:
		- The corresponding RAN4 requirements for intra-frequency and inter-frequency w/wo gaps may not be satisfied when the max RTD among the cells on which UE is required to perform simultaneous L1-RSRP measurement on the same frequency layer is larger than CP length of the cell on the frequency layer.
		- If in one active BWP, there are more than one LTM L1 measurement frequency layers, the corresponding RAN4 requirements for intra-frequency and inter-frequency without gaps may not be satisfied when the max RTD among the cells on which UE is required to perform simultaneous L1-RSRP measurement in the same active BWP is larger than CP length of the cell in the same active BWP.
	+ Proposal 2 (vivo): Adopt the optimizations on consequence of not supporting 39-2/3/4/5/6 as following, , as shown in Table 1:
		- There is no additional limitation on ‘xxx’ for L1 measurement, on top of 39-3-1 and any other reported FG(s) in 39-3-2/3/4/5/6.
	+ Proposal 3 (Ericsson, QC): For 39-3-2/3/4/5/6, there is no need to add separate behaviour if UE does not report support this capability.

# 6. Topic #6: LTM – Performance

## 6.1 Sub-topic 6-1 L1-RSRP measurement accuracy

**Issue 6-1-1: Definition of L1-RSRP measurement relative accuracy**

**<Way Forward >:** Further discuss the following proposal:

* + The intra-frequency relative accuracy of SSB based L1-RSRP is defined as the L1-RSRP measured from one SSB compared to the value of L1-RSRP measured from another SSB of the cell(s) on the same frequency, or between any two SSBs measured on the same cell.

< **Tentative Agreement**>:

* + The inter-frequency relative accuracy of SSB based L1-RSRP is defined as the L1-RSRP measured from one SSB compared to the value of L1-RSRP measured from another SSB of the cell(s) on a different frequency.
	+ Intra-f relative accuracy requirements are also applicable to two SSBs from cells on the same frequency but not the same frequency as serving cell. Inter-f relative accuracy requirements are also applicable to the case that one SSB is on serving cell frequency and another is on a different frequency.

## 6.2 Sub-topic 6-2 Test cases

**Issue 6-2-1: More test or sub-test cases for cell switch delay**

*Ad hoc agreement*

< **Agreement**>:

* + Define only one test case for cell switch without L1 measurement configuration in FR1.
		- RACH-less is configured in the test
		- Intra-frequency cell switch is configured in the test
		- Note: this test case is only applicable to UE supporting early TA acquisition.

**Issue 6-2-2: More test cases for PDCCH-order RACH**

*Ad hoc agreement*

< **Agreement**>:

* + Define only one test case for PDCCH-order RACH without L1 measurement configuration in FR1.
		- Intra-frequency is configured in the test
		- Note: this test case is only applicable to UE supporting early TA acquisition.

**Issue 6-2-3: Whether to have test with two neighbor cells in FR2 for intra-frequency L1-RSRP measurement**

*Online agreement*

< **Agreement**>:

* + Not introduce test with two neighbor cells in FR2 for intra-frequency L1-RSRP measurement to verify the UE behaviour.

**Issue 6-2-4: Whether define test cases for UE-based TA measurement**

*Online agreement*

< **Agreement**>:

* + Not define dedicated test cases for UE based TA measurement for LTM.

**Issue 6-2-5: TCI state configurations**

* Proposals
	+ Proposal 1 (vivo): In RRM test case design for LTM, RAN4 avoid TCI configuration with ‘QCL-D’ or ‘UL TCI’ to UE in FR1, which means only Joint TCI with QCL-A/C configuration, and pathloss RS configuration if necessary, shall be provided to UE in FR1, even if UE supports ltm-MAC-CE-SeparateTCI-r18.

< **Way Forward**>: Discuss in the CR directly.

**Issue 6-2-6: L3 measurement configurations in the test**

* Proposals
	+ Proposal 1 (vivo):
		- For L3 measurement configurations in LTM L1 measurement tests and cell switch delay tests, reportQuantityRS-Indexes and maxNrofRS-IndexesToReport shall be configured.

< **Way Forward**>: Discuss in the CR directly.