**3GPP TSG-RAN WG4 Meeting # 109 R4-232xxxxx**

**Chicago, US, Nov. 13 – Nov. 17, 2023**

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

**Agenda Item:** 8.24.6

**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.
* **Note that L1-RSRP measurement in Topic#2 refers to the baseline “UE is NOT expected to use L3 measurement results for intra-frequency or inter-frequency L1 measurement report” unless otherwise specified.**

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

## Sub-topic 1-1 DL synchronization before cell switch command

**Issue 1-1-1: When to acquire SFN of the candidate cell**

*Ad hoc agreement*

**< Agreement>**:

* + Assuming there is no FDD above 3GHz, RAN4 requirements do not apply for the following FR2 inter-frequency cases:
		- NW doesn’t configure UE to perform neither L3 measurement with SSB index nor L1 measurement before triggering RACH toward neighbour cell or cell switch, and
		- SFN of serving cell from which the PDCCH order/cell switch command is received and target cell are different.

**Issue 1-1-2: Whether and how to define TCI state activation delay requirements for early T/F tracking before cell switch command**

*Ad hoc agreement*

**< Agreement>**:

* + RAN4 to define a time gap between TCI state activation and PDCCH order RACH or cell switch. If PDCCH order or cell switch cmd is received before the time gap, additional time for T/F tracking in PDCCH order RACH delay or cell switch delay requirement is needed.

**Issue 1-1-3: Whether UE shall be able to maintain PL-RS associated with or included in the UL or joint TCI states in the LTM candidate cell active TCI state list**

**<Way Forward>:**

* + To be discussed in “Issue 3-2-3-1: Extra time for PL-RS measurement”
	+ This issue is closed.

**Issue 1-1-4: Others**

**<Tentative Agreement>**

* + Update the agreement

From: For UE not supporting using L3 measurement in L1 report, only if UE is capable of performing LTM L1 measurements for RTD > CP and supports TCI state activation on neighbour cell before cell switch command, then UE supports TCI state activation on neighbour cell before cell switch command when RTD>CP.

To: For UE not supporting using L3 measurement in L1 report, only if UE is capable of performing LTM L1 measurements for RTD > CP and supports TCI state activation on neighbour cell before cell switch command, all the requirements defined for TCI state pre-activation before cell switch command if any, are applicable when RTD>CP.

## Sub-topic 1-2 PDCCH-order RACH on neighbor cell

#### 1.2.1 Delay requirements

**Issue 1-2-1-1: Further clarification on the condition when additional time for DL synchronization needed in the delay requirements for PDCCH ordered RACH before cell switch command**

|  |  |  |
| --- | --- | --- |
| TCI state#1 of cell#1 is in the active TCI state listTCI state#2 of cell#1 is not in the active TCI state list | TCI state or SSB index to use | Whether additional time for SSB based T/F tracking is needed? |
| 1st sub-bullet | TCI state#1 | No (agreed) |
| 2nd sub-bullet | TCI state#2 | FFS |

**<Tentative Agreement>:**

Option a: (Nokia, Apple, MTK, ZTE, HW, vivo, OPPO, Xiaomi)

* If SSB index indicated in PDCCH order is not in the active TCI state list that has been activated, one complete SSB burst is needed for fine time tracking.
* Further optimization in future release.

Option b: (E///, MTK)

* If SSB index indicated in PDCCH order is not in the active TCI state list
	+ If some of the TCI state of the target cell is activated additional time for T/F tracking is not needed under the following conditions:
	+ the arrival timing of different SSBs from the same cell is within [260ns]
	+ SNR if the active TCI state is always above -3dB since it is activated.
	+ Target cell is in FR1.
* Otherwise, one complete SSB burst is needed for fine time tracking.

**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>:**

* + TBA

**Issue 1-2-1-3: The value of additional time for RF/BB preparation and RF re-tuning: when PRACH bandwidth is not within any of the configured UL BWPs of any active serving cell**

**< Tentative Agreement>**

* + For the case of PRACH bandwidth not within any of the configured UL BWPs of any active serving cell
		- Introduce UE capability to report the time needed for RF/BB preparation and RF retuning, down-select from [1ms, 3ms, 5ms, 8ms, 10ms, 15ms].

#### 1.2.2 Interruption requirements

**Issue 1-2-2-1: Interruption due to RF/BB retuning to target cell before RACH transmission or retuning back to serving cell after RACH transmission: when PRACH bandwidth is not within any of the configured UL BWPs of any active serving cell**

*Ad hoc Agreement*

**< Agreement>**

* + The interruption on both UL and DL is Y, which is up to UE capability. Candidate values for Y: 0.25ms, 0.5ms, 1ms and 2ms.

**Issue 1-2-2-2: Location of interruption due to RF/BB retuning to target cell before RACH transmission or retuning back to serving cell after RACH transmission**

*Ad hoc Agreement*

**< Agreement>**

* + Location of the interruption due to RF retuning is before and after the RACH transmission.

#### 1.2.3 UL timing

**Issue 1-2-3-1: n-TimingAdvanceOffset**

*Online Agreement*

**< Agreement>**

* + n-TimingAdvanceOffset is necessary for UE. Send LS to RAN2 and cc RAN1. Work on the wording offline.
	+ RAN4 agreement (not captured in the RAN2 LS)
		- In the derivation of UL timing of PDCCH-ordered RACH on target neighboring cell, DL timing of the target neighboring cell which to transmit UL on should be used as a reference unless further agreement in other WG. If any further agreement in other WG, RAN4 will follow the agreement.

**Issue 1-2-3-2: Whether to define UL adjustment timing requirements for the first UL on target cell before cell switch command, i.e. PDCCH ordered RACH**

**< Tentative Agreement >:**

* + Discuss this issue in maintenance part if RAN1/2 agrees to support using UE based TA measurement to adjust the UL timing of PDCCH ordered RACH on target cell in Nov. meeting.

## 1.3 Sub-topic 1-3 UE based TA measurement

**Issue 1-3-1: Whether and how to define timing requirements for UE based TA measurement**

*Ad hoc*

**< Tentative Agreement >:**

* + Option a: MTK, QC, Apple, ZTE, OPPO, Xiaomi
		- Not to define requirements for UE based TA measurement in R18
	+ Option b: CMCC, vivo
		- define timing requirements for UE-based TA measurement, and the timing requirements introduced for UE based TA measurement in R18 positioning WI can be reused. NW can enable this feature when cells are well synchronized.

# Topic #2: LTM - L1-RSRP (Baseline) measurement requirements

## 2.1 Sub-topic 2-1 Applicability rule for L1-RSRP measurement

**Issue 2-1-1: Whether L1 measurement layer is configured on the same frequency as one of current L3 MO**

*Online Agreement*

**<Agreement>**

* + In Rel-18, for LTM L1 measurement, RAN4 RRM requirements are applicable only if L1 measurement layer is configured on the same frequency as one of current L3 MO.
	+ Note: From network configuration perspective, whether this limitation is not needed is up to other WG agreement.

**Issue 2-1-2: Updating on agreement of L1 measurements on unknown cell**

**<Tentative Agreement>**

* + Update the following agreement:

From: UE is not required to perform L1 measurements on unknown cell.

To: L1 measurement requirements are NOT applied to unknown candidate cells.

**Issue 2-1-3:** **known cell condition for L1-RSRP measurement**

*Ad hoc Agreement*

**< Agreement>**

* + Add the time constraint “The UE has performed L3 measurement on the target cell during the last [X] seconds” in known cell condition for L1-RSRP measurement.

**Issue 2-1-4: How to get SSB index information (on which symbols the RS to-be-measured) of the to-be-measured neighbor cell before L1-RSRP measurement?**

***For information***

|  |
| --- |
| **RAN4#108****Common understanding:** If *deriveSSB-IndexFromCell* or *deriveSSB-IndexFromCellInter* is enabled, UE can derive SSB index according to serving cell timing. |

**<Tentative Agreement>**

* + If deriveSSB-IndexFromCell and deriveSSB-IndexFromCellInter-r17 are not enabled, but UE **has performed** L3 measurement with SSB index on the candidate cell, no additional time is needed
	+ If deriveSSB-IndexFromCell and deriveSSB-IndexFromCellInter-r17 are not enabled, and UE **has not performed** L3 measurement without SSB index reading on the candidate cell, additional time for time index detection is needed.

## 2.2 Sub-topic 2-2 Measurement capability

**Issue 2-2-1: Intra-frequency layers to measure**

**<Tentative Agreement>**

* + For L1-RSRP measurement on neighbour cell, UE measures only one intra-frequency layer on each FR2 band in CA scenario.
		- Selection of the single layer for intra-frequency measurement on a FR2 band shall follow existing L3 measurement, i.e, this single intra-frequency layer shall be:
			* PCC when UE is configured with SA NR operation mode with PCC in the band; or
			* PSCC when UE is configured with EN-DC with PSCC in the band; or
			* PSCC when UE is configured with NR-DC with PSCC in the band; or
			* One of the SCCs on which UE is configured to report SSB based measurements when neither PCC nor PSCC is in the same band, so that the selected SCC shall be an SCC where the UE is configured with SS-RSRP measurement reporting if such SCC exists, otherwise the selected SCC is determined by UE implementation.

**Issue 2-2-2: How to handle the case that the number of cells NW configured/activated to measure exceeds the configuration to exceed UE capability (# of cells/SSBs UE supported per frequency layer)**

*Background:*

|  |
| --- |
| **Conclusion (RAN1#113)*** For the beam selection for SSB based L1-RSRP measurement report, except SpCell is configured to be included,
	+ the selection of cells for the L1 measurement report is up to UE implementation.

the selection of beams per cell for the L1 measurement report is the same as legacy behaviour. |

*To address Nokia’s question on “configured/activated”: There are periodic report, semi-persistent report and aperiodic report for L1-RSRS measurement. For periodic report, there is only RRC configuration. For semi-persistent and aperiodic report, except RRC configuration, there is also related mechanism to active part of the measurement. Here “the number of cells NW configured/activated to measure” is referring to the cells that NW is asking UE to measure, including periodic report, semi-persistent report and aperiodic report.*

**<Tentative Agreement>**

* + In Rel-18, if the number of cells/SSB NW configured/activated to measure exceeds UE capability, it is up to UE implementation on how to choose cells/SSB to measure.

## 2.3 Sub-topic 2-3 Intra-frequency L1-RSRP Measurement delay

#### 2.3.1 Scenario and basic assumption

**Issue 2-3-1-1: whether to support the case that SSB periodicity of FR2 intra-frequency neighbour cell equals to SMTC periodicity in R18 LTM**

*Ad hoc Agreement*

**< Agreement>**

* + Scenario of SSB periodicity of FR2 intra-frequency neighbour cell equals to SMTC periodicity in R18 LTM is supported.
	+ Agree the following as baseline:
		- [When the SSB periodicity of FR2 intra-frequency cell is fully overlapped with SMTC periodicity of inter-frequency neighbour cell, the existing sharing factor P used for L1/L3 measurements can be reused, i.e., P =3 for L1 measurement and P=1.5 for L3 measurement.]
	+ Further discuss whether to support the following optimization:
		- In FR2, L1-RSRP measurement period of less than 160ms is only possible under following conditions. RAN4 to discuss the feasibility of it and methods to achieve 160ms L1-RSRP measurement period.
			* L3 measurements are suspended after TCI state activation
			* N is 1 or reduced to some other value smaller than 8 (i.e., beam sweeping or reduced after TCI state activation for certain time)
		- RAN4 to find a method to achieve less than 160ms measurement period or a method to skip fine time tracking (e.g., by performing fine time tracking in parallel to UE processing). If RAN4 did not find a method to achieve less than 160ms L1-RSRP periodicity or a method to remove fine time tracking from the cell switch delay, for at least one configuration, RAN4 to send LS to RAN1 and RAN2 to convey pre-sync or pre-TCI state activation is not suitable/applicable for FR2.

**Issue 2-3-1-2: whether to consider** **L1-RSRP measurement on deactivated SCell**

**<Tentative Agreement>**

* + Discuss this issue in maintenance part if RAN1/2 agree to support L1-RSRP measurement on deactivated SCell in Nov. meeting.

#### 2.3.2 UE incapable of RTD>CP or UE incapable of measuring multiple cells on the same OFDM symbol when actual RTD>CP

**Issue 2-3-2-1: Measurement period for UE incapable of RTD>CP or UE incapable of measuring multiple cells on the same OFDM symbol when actual RTD>CP**

**<Agreement>**

* + TBA

#### 2.3.3 UE capable of RTD>CP

**Issue 2-3-3-1: Measurement period of intra-frequency L1-RSRP measurement for UE capable of RTD>CP in FR1 if UE performs L1-RSRP measurement on multiple intra-frequency layer**

**<Tentative Agreement>**

* + For multiple intra-frequency layers, additional scaling factor (i.e., **number of frequency layers including intra-frequency and inter-frequency without gap if supported and configured**) is to be scaled on top of measurement period specified for single frequency layer.

**Issue 2-3-3-2: Measurement period of intra-frequency L1-RSRP measurement in FR2 if UE performs L1-RSRP measurement on multiple intra-frequency layer**

**<Tentative Agreement>**

* + For UE capable of RTD>CP, when TCI states of multiple intra-frequency neighbour cells are activated, the measurement delay of the neighbour cells whose TCI state(s) are activated is R15/R16 SSB based L1-RSRP measurement period scaled by 3 x number of intra-frequency neighbour cells whose TCI state(s) are activated.

**Issue 2-3-3-3: Scheduling restriction of intra-frequency L1-RSRP measurement for UE capable of RTD>CP**

*Ad hoc Agreement*

**< Agreement>**

* + Scheduling restriction of intra-frequency L1-RSRP measurement for UE capable of RTD>CP
		- For FR2:
			* For UE capable of RTD>CP, scheduling restriction should be extended by one more symbol before and after SSB symbols.
		- For FR1:
			* FFS. Discuss scheduling restriction case by case.

## 2.4 Sub-topic 2-4 Inter-frequency L1-RSRP

#### 2.4.1 L1 inter-frequency with Type 1 MG

**Issue 2-4-1-1: The principles in defining inter-frequency L1-RSRP measurement period with MG in FR1**

*For information:*

|  |
| --- |
| *RAN4#108***Issue 2-5-2-2: The principles in defining inter-frequency L1-RSRP measurement period with MG in FR1**< **Agreement**>:* + In FR1, within one gap occasion,
		- If L1-RSRP and L3 measurement of the same frequency layer overlap, they can be counted as same frequency layer when calculating CSSF.
		- FFS: Otherwise, L1 inter-frequency measurement on a frequency layer is considered as an independent frequency layer when calculating CSSF for other overlapped inter-frequency layers.
 |



**<Tentative Agreement>**

* + In FR1, within one gap occasion, if there is L1 measurement but no L3 MO on the same frequency layer, the L1-RSRP measurement is regarded as one independent candidate to be measured in a gap when calculating CSSF for other overlapped inter-frequency layers.

**Issue 2-4-1-2: Number of SSB periods needed in inter-frequency L1-RSRP measurement period with Type 1 MG**

**<Tentative Agreement>**

* + For inter-frequency L1-RSRP measurement with MG, the number of samples
		- M = [1 or 2] if higher layer parameter *timeRestrictionForChannelMeasurement* is configured,
		- Otherwise M= [3 or 4].

**Issue 2-4-1-3: inter-frequency L1-RSRP measurement period with MG in FR1**

**<Tentative Agreement>**

* + Define inter-frequency L1-RSRP measurement period with MG in FR1 as:

|  |  |
| --- | --- |
| **Condition** | **T L1-RSRP\_SSB\_measurement\_period\_inter** |
| No DRX | Max(Treport, Ceil(M \* Kgap) × Max(MGRP, SSB period)) × CSSFinter |
| DRX cycle ≤ 320ms | Max(Treport, Ceil(M × 1.5 \* Kgap) × Max(MGRP, SSB period, DRX cycle)) × CSSFinter |
| DRX cycle > 320ms | Ceil(M \* Kgap) × DRX cycle × CSSFinter |
| The definition of Kgap is the same as L3 measurement which is a scaling factor for a SSB frequency layer to be measured within an associated measurement gap pattern.M = **[1 or 2]** when timeRestrictionForChannelMeasurement is configured. Otherwise M = [**3 or 4**]. |

**Issue 2-4-1-4: inter-frequency L1-RSRP measurement period with MG in FR2**

**<Tentative Agreement>**

* + Define inter-frequency L1-RSRP measurement period with MG in FR2 as:

|  |  |
| --- | --- |
| **Condition** | **T L1-RSRP\_SSB\_measurement\_period\_inter** |
| No DRX | Max(Treport, Ceil(Kgap × M\*N)× Max(MGRP, SSB period)) × CSSFinter |
| DRX cycle ≤ 320ms | Max(Treport, Ceil(1.5 \* Kgap × M\*N) × Max(MGRP, SSB period, DRX cycle)) × CSSFinter |
| DRX cycle > 320ms | Ceil(Kgap × M\*N) × DRX cycle × CSSFinter |
| The definition of Kgap is the same as L3 measurement which is a scaling factor for a SSB frequency layer to be measured within an associated measurement gap pattern.M = [**1 or 2**] when timeRestrictionForChannelMeasurement is configured. Otherwise M = [**3 or 4**]. |

## 2.6 Sub-topic 2-6 Others

**Issue 2-6-1: L1 report for unmeasured candidate cells**

**< Way Forward>**: Further discuss the following proposal in maintenance part

* + Proposal 1 (QC):
		- In L1-RSRP measurement report, for unmeasured candidate cells, UE reports measured quantity value corresponding to one of the invalid codepoints in Table 10.1.6.1-1, preferably RSRP\_0.

**Issue 2-6-2: Additional conditions to perform L1 measurement for LTM**

**< Way Forward>**: Further discuss the following proposal in maintenance part

* + Proposal 1 (Nokia):
		- UE is not required to perform LTM measurements when UE is not in active data transmission.

**Issue 2-6-3: Impact on L3 measurement**

Merged with Issue 2-3-3-1

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

## 3.1 Sub-topic 3-1 Scenarios and General Procedures

**Issue 3-1-1: How to** **specify cell switch delay requirements for PSCell switch**

< **Agreement**>:

* + Reuse LTM PCell switch delay for PSCell.
	+ Define LTM PSCell switch delay requirements in section 8.

**Issue 3-1-2: Procedure of cell switch**

< **Tentative Agreement**>:

* + Due to limited time, further discuss the optimization on cell switch procedure in later releases.

## 3.2 Sub-topic 3-2 Detail of cell switch delay requirements for Pcell/PSCell

#### 3.2.1 Processing time: Tprocessing,2 /T LTM\_processing

**Issue 3-2-1-1: Shorter Processing time?**

< **Tentative Agreement**>: Further discuss whether and how to define a shorter T LTM\_processing in cell switch delay requirements in maintenance part.

* + Option 1 (CATT, Nokia, ZTE, Huawei): Tprocessing,2/ TLTM-processing can be reduced when target Pcell/SCell is current SCell/PCell.
		- Option 1a (CATT)
			* RAN4 to discuss whether and how to differently define the requirements depending on whether the SCell is for DL-only or both DL/UL.
	+ Option 2 (ZTE, MTK, Ericsson): introduce a UE capability for shorter Tprocessing,2/ TLTM-processing.
		- Option 2a (ZTE): Introduce UE capability with up to 2 candidate values, one value is 20ms, and FFS the other one.
		- Option 2b (MTK): The candidate reduced values can be [10ms, 15ms].
		- Option 2c (Ericsson): potential values of 10ms, 20ms.

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

**Issue 3-2-2-1: T/F fine tracking: TΔ and Tmargin**

<**Tentative** **Agreement** >:

* + Follow the agreement of Issue 1-2-1-1.

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

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

<**Tentative** **Agreement** >:

* + No additional delay is needed for PL-RS measurement in cell switch delay.
	+ Further discuss the applicable conditions in maintenance.

#### 3.2.4 Tinterruption

**Issue 3-2-4-1: Tinterruption** **of PCell/PSCell switch**

< **Agreement** >:

* + TBA

## 3.4 Sub-topic 3-3 Known conditions

**Issue 3-3-1: known cell conditions**

*Ad hoc Agreement*

**< Agreement>**

* + - The target cell is known if it has been meeting the following conditions:

- During the last 5 seconds before the reception of the handover cell switch command:

- the UE has sent a valid L1 or L3 measurement report for the target cell and

- One of the SSBs measured from the NR target cell being configured remains detectable according to the cell identification conditions specified in clause 9.2 for intra-frequency cell and in clause 9.3 for inter-frequency cell,

- One of the SSBs measured from the target cell also remains detectable during the cell switch delay according to the cell identification conditions specified in clause 9.2 for intra-frequency cell and in clause 9.3 for inter-frequency cell.

* + - otherwise it is unknown.
		- FFS whether and how to address the mismatch on definition of known between existing HO requirement and cell switch delay requirements.

**Issue 3-4-2: known TCI state conditions**

**< Tentative Agreement >**

* + The target joint DL/UL TCI state or separate DL and UL TCI states in the LTM cell switch command are known if the following conditions are met:
		- The target DL/UL TCI state in the LTM cell switch command is known if the following conditions are met:
			* During the period from the last transmission of the RS resource used for the L1-RSRP measurement reporting for the target DL/UL TCI state to the completion of LTM cell switch, where the RS resource for L1-RSRP measurement is the RS in target DL/UL TCI state or QCLed to the target DL/UL TCI state
				+ LTM cell switch command is received within 1280 ms upon the last transmission of the RS resource for beam reporting or measurement
				+ The UE has sent at least 1 L1-RSRP report for the target DL/UL TCI state before the LTM cell switch command
				+ The target DL/UL TCI state remains detectable during the LTM cell switching period
				+ The SSB associated with the target DL/UL TCI state remain detectable during the cell switching period

SNR of the TCI state ≥ -3dB

* + - Otherwise, the target joint DL/UL TCI state or separate DL and UL TCI state is unknown.

# 4 Topic #4: LTM – Others

## 4.1 Sub-topic 4-1 RAN2 LS

**Issue 4-1-1: Whether to include SMTC in the RS configuration for L1-RSRP measurement**

To be discussed in reply LS to RAN2.

## 4.2. Sub-topic 4-2 Using L3 measurement in L1 report

**Issue 4-1-1: Measurement reporting**

**<Agreement>** TBA

**Issue 4-2-2: NW needs to know UE using L3 results in L1 report or not?**

**<Agreement>** TBA

**Issue 4-2-3: The condition to switch to using L3 results in L1 report**

**<Agreement>** TBA

**Issue 4-2-4: Measurement requirements**

**<Agreement>** TBA

**Issue 4-2-5: TCI state activation and PDCCH-order RACH before cell switch command**

**<Agreement>** TBA

**Issue 4-2-6: Scenarios supported**

**<Agreement>** TBA