3GPP TSG-RAN WG2 Meeting #121-bis electronic \_R2-23xxx

April 17th - 26th, 2023

Agenda Item: 7.4.2.1

Source: Huawei, HiSilicon

**Title:** **Summary of [AT121bis-e][018][eMob] Procedure Consolidation (Huawei)**

Document for: Discussion and Decision

# Introduction

This paper aims at capturing the summary of the offline discussion.

* **[AT121bis-e][018][eMob] Procedure Consolidation (Huawei)**

Scope: 1: Identify agreements (easy / tentative), and Open Issues that should be resolved to consolidate and clarify LTM procedures, can also suggest/indicate wanted updates to procedural descriptions (ST-2)

2: Collect comments on R3 LS and propose resolution.

Use R2-2303549, R2-2302829 as inspiration, Can also include proposals from other papers that seem relevant.

Intended outcome: Report

Deadline: CB W2 Wednesday

Please note the PDCCH order early RACH related issues (like TA maintenance, early RACH config, following questions related the two RAR options, etc) are not included in this LTM procedure offline scope.

**Contact information**

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| **Company** | **Name (Email)** |
| Apple | Naveen Palle (naveen.palle@apple) |
| Ericsson | Antonino Orsino (antonino.orsino@ericsson.com) |
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**Endorsed 38.300 CR procedure**

Followings are copied from the last meeting endorsed running CR R2-2302039.



**Figure x. Signaling procedure for LTM**

The procedure for LTM is as follows.

1. The UE sends a *MeasurementReport* message to the gNB. The gNB decides to use LTM and initiates candidate cell(s) preparation.

2. The gNB transmits an *RRCReconfiguration* message to the UE including the LTM candidate cell configurations of one or multiple candidate cells.

3. The UE stores the LTM candidate cell configurations and transmits a *RRCReconfigurationComplete* message to the gNB.

4a/4b. The UE may perform DL synchronization and TA acquisition with candidate cell(s) before receiving the cell switch command.

Editor’s note: DL synchronization for candidate cell(s) before cell switch command is supported, at least based on SSB. FFS necessary mechanism.

Editor’s note: TA acquisition of candidate cell(s) before LTM cell switch command is supported, at least based on PDCCH ordered RACH, where the PDCCH order is only triggered by source cell. FFS detailed mechanism.

5. The UE performs L1 measurements on the configured candidate cell(s), and transmits lower-layer measurement reports to the gNB.

Editor’s note: FFS whether the lower-layer measurement reports are carried on L1 or MAC.

Editor’s note: The order of DL/UL sync (step 4a/4b) and L1 measurement (step 5) is not defined and subject to change.

6. The gNB decides to execute cell switch to a target cell, and transmits a MAC CE triggering cell switch by including the candidate configuration index of the target cell. The UE switches to the configuration of the target cell.

Editor’s note: FFS how beam indication is done.

7. The UE performs random access procedure towards the target cell, if cell switch needs to include performing random access procedure.

8. The UE indicates successful completion of the cell switch towards the target cell.

The UE can perform the steps 4-8 multiple times for subsequent LTM cell swith based on the configuration provided in step 2.

Editor’s note: FFS whether a uplink signal or message after the UE has switched to the target cell is used to indicate successful completion of the LTM cell switch.

# Discussion

**2.1 RRCReconfigurationComplete message transmission**

Several motivations was mentioned that UE should send the RRCReconfigurationComplete message to the target cell upon LTM execution:

* The agreed RRC modelling1 implies the corresponding RRCReconfigurationComplete message to the target cell is reasonable.
* The RRCReconfigurationComplete message to the target cell is useful to include the uplinkTXDirectCurrent, needForGaps, etc information as supported in legacy.
* It can be the UE arrival indication or LTM completion indication to the target cell.

**Question 1: do you agree the RRCReconfigurationComplete message is always sent at each LTM execution?**

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| **Companies** | **Yes or No?** | **Comments** |
| Apple | No | We do not think sending this every time is useful. Would like to keep the L2 based mechanism as is… UE can send an RRC message if needed (UE triggered if the need arises) |
| Ericsson | Yes | Since in the last meeting it was agreed to support the RRC model 1, sending the RRCReconfigurationComplete message is a natural consequence.  Enhancements on this specific case are not needed, without considering the fact that modify the legacy L2 mechanism (RRCReconfiguration+RRCReconfigurationComplete) may have big implication from a specification point of view.  Since we already have a lot of our plate to discussion, we prefer to keep this simple and re-use he legacy procedure. |
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**2.2 LTM completion determination**

### A: NW side to determine the UE arrival

Several companies want to clarify how the target cell NW side determines the UE arrival/LTM completion during LTM execution.

Please input your understanding on this LTM completion issue.

**Question 2a: do you agree, in RACH-based LTM, the target cell is aware of the UE’s arrival based on the reception of Msg1 in CFRA and on the reception of Msg3 in CBRA, like the legacy HO?**

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| **Companies** | **Yes or No?** | **Comments** |
| Apple | Yes |  |
| Ericsson | Yes |  |
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**Question 2b: do you agree, in RACH-less LTM, the target cell is aware of the UE’s arrival based on reception of the first UL transmission from this UE?**

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| **Companies** | **Yes or No?** | **Comments** |
| Apple | Yes | For eg with MAC CE with pre-given identifier like C-RNTI |
| Ericsson | Yes |  |
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Then the following question would be the content of this first UL MAC PDU/transmission in RACH-less LTM.

The baseline can always be that any buffered DRB/SRB data can be sent by the first UL data based on LCP procedure. So, if the *ReconfigurationComplete* is to be sent in Question 1, there is no need to introduce any new explicitly manner (e.g. new MAC CE). Also, any other legacy pending MAC CEs or triggered SR can be sent upon LTM execution to target cell.

**Question 2c: In RACH-less LTM, what’s your understanding on the content of the first UL MAC PDU/transmission to indicate UE arrival? Do we need to introduce any new signaling to indicate UE arrival?**

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| **Companies** | **Yes or No** on the need of any new signaling**?** | **Comments** (please clarify your views on the content of the first UL transmission in RACH-less LTM) |
| Apple | Yes | For eg with MAC CE with pre-given identifier like C-RNTI |
| Ericsson | No | For RACH-less LTM, our understanding is the following:   * The UE has a grant provided in the LTM candidate cell configuration and thus it may already do the first UL transmission after receiving the LTM cell switch command. * The UE does not have a grant provided in the LTM candidate cell configuration. In this case the UE will listen to PDCCH in order to receive a grant from the network. After this the UE will do the first UL transmission.   In both cases the first UL tranmission will be the RRCReconfigurationComplete message and thus there is no need to specify any new signalling. |
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### B: UE side to determine the LTM completion

It is also important to clarify the UE side behavior on how to determine the LTM successful completion, which may be related the handling of LTM timer.

**Question 2d: do you agree, for RACH-based LTM, the UE considers that LTM execution procedure is successfully completed when the RACH is successfully completed?**

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| **Companies** | **Yes or No?** | **Comments** |
| Apple | Yes |  |
| Ericsson | Yes |  |
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**Question 2e: do you agree, for RACH-less LTM, the UE considers that LTM execution procedure is successfully complete when the UE determines the NW has successfully received its first UL data?**

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| **Companies** | **Yes or No?** | **Comments** |
| Apple | Yes |  |
| Ericsson | Yes |  |
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In addition, in RACH-less LTM cell switch, companies have different proposals on how the UE determines the NW acknowledge of its first UL data. Please clarify your view on how the UE determine this successful reception by NW, e.g. C-RNTI addressed PDCCH, new DL MAC CE, etc.

**Question 2f: In RACH-less LTM cell switch, how the UE determines the successful reception of its first UL data by NW.**

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| **Companies** | **Option?** | **Comments** |
| Apple | Several | NDI toggle for UL grant, DL MAC CE etc.. RAN2 can decide on one.. C-RNTI addressed PDCCH might not provide confirmation at the UE that NW has received successfully… |
| Ericsson | Reception of the RRC reconfiguration complete message | Upon an LTM cell switch the UE will send the RRCReconfigurationComplete message and this message is sent over RLC AM. In this case the UE can determine that this message has been received by the network. |
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**2.3 LTM failure handling**

### A: LTM supervisor timer

It seems companies have quite similar view on the T304-like timer for LTM.

**Question 3a: Do you agree with following behaviors of LTM supervisor timer?**

* **1: The UE starts the LTM supervisor timer, upon reception of the LTM cell switch MAC CE;**
* **2: The UE stops the LTM supervisor timer, upon successful completion of LTM cell switch;**
* **3: If the LTM supervisor timer expires, the UE considers LTM failure and initiates RRC re-establishment.**

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| **Companies** | **Yes or No?** | **Comments** |
| Apple | Yes | Agree to all 3 |
| Ericsson | Yes |  |
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**Question 3b: Do you think the LTM supervisor timer is RRC layer timer or MAC layer timer?**

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| **Companies** | **RRC or MAC?** | **Comments** |
| Apple | MAC | RRC might not even be aware of the LTM cell switch MAC CE. |
| Ericsson | RRC | Our preference would be to have an RRC timer as a MAC timer may implicate a lot of cross-coordination between the MAC and RRC layers.  Further, when the LTM MAC CE command is received the MAC layer needs to indicate anyway this to the RRC layer, so the RRC is well aware on when a cell switch command is received.  In addition to this, for RACH-less case since the UE will need to send the RRCReconfigurationComplete message the RRC layer is already aware of when the timer needs to be stopped. |
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### B: LTM execution in failure case

It is also proposed to reuse the CHO like solution to handle the LTM failure case.

**Question 3c: Do you agree that, at RLF or LTM execution failure, if the UE performs cell selection and the selected cell is an LTM candidate cell, the UE can perform LTM execution to the selected cell (like CHO)?**

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| **Companies** | **Yes or No?** | **Comments** |
| Apple | No | LTM execution can also be from a CFRA or RACH less, and other target LTM cells might be ready, or pro-visioned for this UE yet. |
| Ericsson | In principle yes, but | We think that the baseline should be for the UE to trigger the RRC re-establishment.  If we want to go beyond this, of course there are different ways for the UE to do a fast recovery but more discussions are needed and all the options needs to be evaluated.  Probably is too early to reach an agreement on this. |
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**2.4 Coexistence with L3 handover**

Followings are proposed on the co-existence between L3 handover and LTM:

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| **R2-2303549**  Proposal 8a: While configured with LTM candidate cells, the UE can also execute any L3 handover command sent by the network.  Proposal 8b: It is up to NW to avoid any issue due to the case when UE receives the LTM MAC CE and RRCReconfiguration message in the same MAC PDU.  **R2-2303869**  Proposal 4-1: Both LTM and L3 HO independently configured and triggered by each anchor point.  **R2-2302830**  Proposal 1a: RAN2 to discuss the first race condition between delivering an RRC message to a UE and triggering inter-DU LTM by the UE.  Proposal 1b: RAN2 to discuss the dilemma of whether the CU should retransmit a missed RRC message to the UE via the new serving DU for the first race condition.  Proposal 2a: RAN2 to discuss the second race condition between processing an RRC message received right before LTM is triggered and execution of inter-DU LTM.  Proposal 2b: RAN2 to discuss how the UE determines whether to apply or discard the RRC message for the second race condition. RAN2 to discuss how the Gnb and the UE would stay in sync on the right UE behavior. |

It is good to discuss/conclude whether RAN2 needs to handle/specify anything to handle the collision/co-existence/race conditions.

**Question 4: Do you agree (basically no RAN2 work):**

1. **While configured with LTM candidate cells, the UE can also execute any L3 handover command sent by the network.**
2. **It is up to the network to avoid any issue due to the case when UE receives the LTM MAC CE and RRCReconfiguration message (e.g. L3 HO cmd) in the same MAC PDU. Mainly RAN3 work to address this. No UE behavior impact.**

If you have different understanding, please clarify what RAN2 needs to specify.

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| **Companies** | **Yes or No?** | **Comments** |
| Apple | Yes | agree |
| Ericsson | Yes but | The race condition is not only limited to the case on the the LTM cell switch and L3 HO command are received within the same MAC PDU. Therefore, the point 2 is not enterely correct.  However, we believe that RAN3 needs to discuss this and RAN2 may simply follow their agreements. |
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**2.5 RAN3 LS about inter-DU coordination**

Following approaches are asked by RAN3:

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| RAN3 has discussed the following two approaches to support inter-DU LTM cell switch during execution.  **Approach 1**: the serving gNB-DU triggers the execution by transmitting LTM cell switch command to the UE and then informs the gNB-CU of the serving cell switch.  **Approach 2**: the serving gNB-DU first requests information from target DU before triggering LTM cell switch command to the UE.  RAN3 would like to get feedback from RAN2 about the above-mentioned approaches, and provide suggestion if there is any other possibility identified. |

Based on the contributions, it seems majority are fine to assume at least approach 1 or both approach 1+2 to be supported. Then, the discussion can focus on whether we need approach 2 or whether approach 2 is necessary.

The technical observations are list below from contributions:

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| **R2-2303549**  Observation 1: Any checking/confirmation with target gNB-DU about the candidate cell can be done in the LTM preparation phase, rather than in the later cell switch decision phase.  Proposal 1a: RAN2 confirm the LTM cell switch decision (i.e. when to switch and which cell to switch to) is made by the gNB-DU in the intra-DU case and by the source gNB-DU in the inter-DU case.  Proposal 1b: In the cell switch decision phase, avoid CU-DU interactions (e.g. requesting information from target DU) to determine the content in the LTM MAC CE at the time of sending the cell switch command.  **R2-2302507**  Proposal 1: For RACH-less LTM of inter-DU case, the serving gNB-DU is not required to request information (e.g., the one to be included in LTM cell switch command) from target DU immediately before triggering LTM cell switch command to the UE.  **R2-2302804**  Proposal 4: From RAN2 perspective, source DU could trigger inter-DU LTM without requiring the target DU, i.e. as the extra exchange between source and target DUs leads to longer handover latency which beats the motivation of introducing the LTM and high potential RLF rate.  **R2-2302829**  Proposal 6: Only information that may be requested by the serving DU from the target DU is that information a serving DU would need to determine the content of the LTM MAC CE.  Observation 3a: The serving DU determines which candidate configuration index to include in the LTM MAC CE based on cell info included in the L1 measurement report. The CU shall provide a mapping of cell info to configuration indices to the serving DU during LTM preparation.  Observation 3b: The serving DU determines which TCI state of the candidate cell to include in the LTM MAC CE based on beam info received in the L1 measurement report. The CU shall provide TCI state configuration of the candidate cell to the serving DU during LTM preparation.  Observation 3c: The candidate DU proactively forwards the TA value to the serving DU during early TA acquisition if RAR reception from the candidate cell is not configured for the UE.  Proposal 1: Reply to RAN3 the following:   * For Approach 1:   + Approach 1 is feasible from RAN2 perspective but requires the following:     - * The serving DU needs to be configured by the CU during LTM preparation phase with a mapping b/w the candidate cell indication in the UE’s L1 measurement report and the corresponding candidate configuration index.       * The serving DU needs to receive from the CU during LTM preparation phase the UE’s TCI state configuration of the candidate cell.       * For RACH-less LTM, the candidate DU should proactively send the TA value to the serving DU for the case that RAR reception from the candidate cell is not configured during early TA acquisition.   + RAN2 respectfully requests RAN3 to handle the signaling for the above requirements. * For Approach 2:   + RAN2 could not identify an example of information that needs to be actively requested by the serving DU from the candidate DU prior to the triggering of LTM execution.   + RAN2 assumes that the serving DU does not defer the triggering of LTM if urgency to trigger LTM is indicated by the UE’s L1 measurement report to avoid sending the UE to RLF.   **R2-2303751**  In conclusion, Approach 2 supports TA acquisition/update by PDCCH ordered RACH without RAR reception, whereas Approach 1 may not.  From above, we observe that a cell switch command transmission at S-DU without CU confirmation (i.e. Approach 1) can cause race conditions that may lead to initiation of the RRC connection reestablisment procedure or confusion of RRC message processing at both UE and network.  Proposal 2. RAN2 supports Approach 2, i.e., the serving gNB-DU first requests information from target DU before triggering LTM cell switch command to the UE.  **R2-2304102**  [Observation 3 In approach 1, the candidate DU needs to be prepared for the UE arriving in target cell already after LTM candidate cell configuration.](#_Toc131756984)  [Observation 4 If only approach 1 is supported, we need to put restrictions on which dynamic information that can be included into the LTM cell switch command, also for the intra-DU case.](#_Toc131756985)  [Observation 5 Approach 2 for execution enables the CU and candidate DU to reject the execution and avoids race conditions between LTM and RRC procedures such as L3 mobility.](#_Toc131756986)  [Observation 6 In approach 2 for execution (LTM triggering with target candidate DU involvement), just as in the intra-DU case, it is possible to include dynamic information in the LTM cell switch command.](#_Toc131756987)  [Observation 7 In approach 2 for execution, just as in the intra-DU case, the target DU is aware of that the UE is about to arrive at the time LTM cell switch is executed. This enables the candidate DU to allocate resources in the target cell later.](#_Toc131756988)  [Observation 8 When using approach 2 for execution, the latency before LTM cell switch is triggered is increased with two F1AP round trip procedure delays.](#_Toc131756989)  [Observation 9 If approach 2 is specified, also approach 1 can be used by a network implementation, given this is supported by F1AP.](#_Toc131756990) |

Some clarification on the approaches:

Approach 1 does not exclude the coordination between source DU and target DU. For example, TA acquisition may requires some source DU and target DU coordination (e.g. target DU informs the TA value to source DU). But “requesting to target DU immediately before” before transmitting LTM MAC CE is not needed.

Some contributions mention the race conditions, which is under discussion in RAN3. But it is not clear why it requires target DU involvement (rather than only CU).

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| **Approach 1**: the serving gNB-DU triggers the execution by transmitting LTM cell switch command to the UE and then informs the gNB-CU of the serving cell switch.  **Approach 2**: the serving gNB-DU first requests information from target DU before triggering LTM cell switch command to the UE. |

**Question 5: Do you agree RAN2 reply RAN3 that:**

1. **Approach 1 is the current RAN2 assumption;**
2. **with the clarification on approach 1 that some coordination between source DU and target DU may be needed before the cell switch decision by source DU, but the requesting from target DU immediately before triggering LTM cell switch command is not necessary/intended;**
3. **RAN2 will let RAN3 know if approach 2 is also needed based on future progress in RAN2.**

If you prefer approach 1, please indicate what information needs to be informed.

If you prefer approach 2, please indicate what information has to be to be requested from target DU, and clarify the time about the wording “before” (long time before or immediately before).

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| **Companies** | **Yes or No?** | **Comments** (better clarify your argument/concern rather than just indicating Y/N) |
| Apple | Pls see details.  We prefer approach #2 | #1 No, target needs to be informed before cell switch.  #2 ok, as long as the target DU is informed sometime in the past and target DU has acknowledged on admitting the UE.  #3 Yes.  Target DU needs to provide RACH resources, TA value or some identifier (like C-RNTI) that is used as identification of the UE at L2 level after cell switch. Without these info, source DU cannot trigget switch.  All of the above are needed for intra-DU, but since the DU is the same, there is no need to put it as a requirement. |
| Ericsson | No with comments | As clarified in our paper, both approach 1 and approach 2 have pros and cons.  **Table 1. Comparison between the two execution approaches**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | |  | Latency before triggering | Dynamic information in LTM cell switch command | CU/candidate DU can reject execution | Avoids race conditions | Reservation of radio resources in target cell | Complexity | | Approach 1 | Almost no latency | Limited | No | Limited | Early | Low | | Approach 2 | Short to medium | Yes | Yes | Yes | Late | Low |   While approach 1 can be considered the baseline, we don’t see why to prevent a network implementation to use approach 2.  Also, good to be aware that approach 1 comes with a series of limitation that we would need to capture in the spec. Simple example are the SCell activation or SCG activation that cannot be provided in the LTM MAC CE.  Further, we don’t see the latency to be a problem. E.g., in approach 2 the candidate DU may provide the grant , RACH resources and other configuration to the UE, and it will also be aware that a UE is coming so is already prepared for the LTM cell switch command. Also, the serving DU may have a more conservative approach and start to contact the candidate DU a bit earlier on when the UE needs to be switched. All in all the latency may be exactly the same.  We don’t see big impact from the RAN2 specification point of view to support both approaches and we can just leave to the network to use one of them.  From the UE point of view, approach 1 and approach 2 are exactly the same so we don’t get how approach 1 and approach 2 impact the connectivity interruption. |
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**2.6 Open issues collection for LTM procedure**

This question is to collect if there is **any other critical open issue** on the **LTM procedure**, in addition to the previous mentioned questions.

Any suggestion to update the procedural descriptions in 38.300 running CR is also welcome, **in additional to the above questions** (which may supposed to be somehow implemented in the stage2 description once agreed).

**Question 6: Any suggestion on any additional open issue for the LTM procedure:**

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| **Companies** | **If any, please clarify the suggested the open issue(s), which is not covered in previous sections, for LTM procedure.** |
| Apple | Handling LTM switch failure and link failure from the perspective of PDCP, if the target cell UE select is also a candidate LTM cell. |
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# Conclusion and proposals

Based on the above summary, following proposals are given.

**Potential agreement for LTM procedure**

**TBD**

**Proposed resolution for RAN3 LS**

**TBD**

**Open Issues for LTM procedure**

**TBD**

**Potential updates to procedural descriptions in 38.300 running CR**

**TBD**

# Reference

1. [R2-2302458](file:///D:\Tdoc%20review\RAN2%23121bis\word\R2-2302458_R3-230889.docx) LS on Approaches during execution for inter-DU LTM (R3-230889; contact: Ericsson) RAN3 LS in
2. [R2-2303549](file:///D:\Tdoc%20review\RAN2%23121bis\word\R2-2303549%20LTM%20procedure%20including%20RAN3%20LS%20and%20miscellaneous%20issues.docx) LTM procedure including RAN3 LS and miscellaneous issues Huawei, HiSilicon
3. [R2-2302829](file:///D:\Tdoc%20review\RAN2%23121bis\word\R2-2302829%20Discussion%20on%20LTM%20procedures.docx) Discussion on LTM procedures Qualcomm Inc.
4. [R2-2303709](file:///D:\Tdoc%20review\RAN2%23121bis\word\R2-2303709%20NR%20MOB%20procedure%20description.docx) LTM Stage 2 open issues Interdigital, Inc.
5. [R2-2302508](file:///D:\Tdoc%20review\RAN2%23121bis\word\R2-2302508%20Discussion%20on%20Applicable%20Scenarios%20and%20Procedure.docx) Discussion on Applicable Scenarios and Procedure CATT
6. [R2-2302804](file:///D:\Tdoc%20review\RAN2%23121bis\word\R2-2302804_Discussion%20on%20LTM%20procedures.docx) Discussion on LTM procedures vivo
7. [R2-2303008](file:///D:\Tdoc%20review\RAN2%23121bis\word\R2-2303008%20LTM%20procedure.docx) LTM procedure for different scenarios Fujitsu
8. [R2-2303024](file:///D:\Tdoc%20review\RAN2%23121bis\word\R2-2303024%20-%20Discussion%20on%20general%20procedure%20for%20LTM.docx) Discussion on general procedure for LTM OPPO
9. [R2-2303425](file:///D:\Tdoc%20review\RAN2%23121bis\word\R2-2303425%20Discussion%20on%20LTM%20overall%20procedure.docx) Discussion on LTM overall procedure ZTE Corporation, Sanechips
10. R2-2303650 LTM stage-2 design models Lenovo
11. [R2-2303751](file:///D:\Tdoc%20review\RAN2%23121bis\word\R2-2303751.docx) Remaining issues of LTM execution procedure LG Electronics
12. [R2-2304102](file:///D:\Tdoc%20review\RAN2%23121bis\word\R2-2304102-%20Discussion%20on%20RAN3%20LS%20on%20approaches%20during%20execution%20for%20inter-DU%20LTM.docx) Discussion on RAN3 LS on approaches during execution for inter-DU LTM Ericsson
13. [R2-2302485](file:///D:\Tdoc%20review\RAN2%23121bis\word\R2-2302485%20Failure%20Handling%20for%20LTM.docx) Failure handling for L1/L2 triggered mobility NEC
14. [R2-2303535](file:///D:\Tdoc%20review\RAN2%23121bis\word\R2-2303535%3fConsiderations%20on%20failure%20handling.doc) Considerations on failure handling CMCC