**3GPP TSG-RAN** **WG2 Meeting #113bis-e R2-210xxxx**

**Electronic, April 12 – 20, 2021**

**Source: Samsung**

**Title: Summary of email discussion [AT113bis-e][035][feMIMO] L1L2 Centric Mobility (Samsung)**

**Document for: Discussion and Decision**

**Agenda Item: 8.17**

# Introduction

This document summarizes the following email discussion.

* [AT113bis-e][035][feMIMO] (Samsung)
* Scope: Progress R2 discussion on the relevant questions in the LS (on a high level). Conclude on whether serving cell change is part of this scope or not (if possible). Identify major discussion points for R2. Determine questions that should be asked to R1, if any.
* Intended outcome: Report, TBD LS out (questions to R1, no reply)
* Deadline: In time for CB Tuesday April 20.

During the online session, RAN2 shotly discussed the L1/L2 centric mobility based on RAN1 LSes [1][2] and RAN2 tried to share the understanding on this issue, but it is unclear what is the RAN1 intention and goal for this issues e.g. whether serving cell change during L1/L2 centric mobility is intended or not.

[R2-2102627](file:///D%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_113bis-e%5CDocs%5CR2-2102627.zip) LS on TCI State Update for L1/L2-Centric Inter-Cell Mobility (R1-2102248; contact: Samsung) RAN1 LS in Rel-16 NR\_feMIMO-Core To:RAN2, RAN3, RAN4 Cc:RAN

DISCUSSION

- Samsung think the main difference between companies’ views is whether this is HO-style mobility or not.

- Intel think we can have offline, and not clear whether serving cell change is needed or not. Intel wonder what is R1 assumption on serving cell change. Samsung think serving cell change is not the intention of the eMIMO WI. Think this might need to be clarified.

- vivo agrees serving cell change need to be clear. Think multi-TRP and BFR are additional topics for R2 in this WI. Think we need to consider TU allocation and scope.

- MTK would prefer to not change serving cell.

- Huawei think that we should start with a simple scenario. Think we shold focus on the first 4 questions.

[R2-2103330](file:///D%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_113bis-e%5CDocs%5CR2-2103330.zip) Considerations on L1/L2 centric inter-cell mobility Samsung discussion Rel-17 TEI17

DISCUSSION

- MTK think the observations are reasonable

- Nokia is wondering whether Multi-TRP paradigm is used or not. Nokia wonder if this is mobility or not.

- QC agrees we shall clarify whether this is multi-TRP. Isn’t it easier to configure these as serving cells.

- Huawei think serving non-serving cell shall be preconfigured. Wonder how data transmission can be done on a non-serving cell. Think we can start on Pcell change. Can focus on intra-DU case.

- vivo thikn that indeed this can be preconfigured. Thikn this is for both multi-TRP and mobility cases.

- Ericsson think R1 may not be clear what serving/non-serving cell is from R2 perspective. Would be good to provide definitions to RAN1.

- Intel think it is unclear from WID whether this is multi-TRP or mobility. The WID seesm to address two cases. Think that as long as the UE is in serving cell coverage multi-TRP can be used, but if serving cell coverage is lost, serving cell change is needed.

- Nokia think we need to determine what is feasible.

In this offline discussion, RAN2 focus on summarizing the RAN2 impact to support L1/L2 centric inter-cell mobility based on what RAN1 agreed.

# Contact Points

Respondents to the email discussion are kindly asked to fill in the following table.

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| --- | --- | --- |
| Company | Name | Email Address |
| Samsung | Seungri Jin | seungri.jin@samsung.com |
| Nokia, Nokia Shanghai Bell | Tero Henttonen | tero.henttonen@nokia.com |
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# Discussion:

In R2-21026625 (LS on Agreements Pertaining to L1/L2-Centric Inter-Cell Mobility)[1], all agreements on L1/L2 centric inter-cell mobility issue are included. First, it is very important RAN2 know what is the scope of this WI especially for support L1/L2 Centric Inter-Cell Mobility. One hint based on the RAN1 agreements in [1] is that RAN1 initially assumed that this feature potentially can extend the Rel-16 mobility mechanism but the main outcome seems to be dynamic TCI state update using the TCI framework for inter-cell case (i.e. to extend Rel-15/16 mTRP operation for intra-cell to inter-cell), see below yellow highlight.

The detail functionalities to support the TCI state update (beam indication) for DL reception from and UL transmission to non-serving cell(s) – at least on UE-dedicated PDSCH, PDCCH, PUSCH, and PUCCH are also listed as green highlight below. According to this required functionalities,

1. UE receives from serving cell, configuration of SSBs/CSI-RSs of non serving cell for beam measurement.
2. UE performs beam measurement for non-serving cell and report it to serving cell.
3. Based on the above reports, TCI state of non-serving cell is activated from the serving cell (by L1/L2 signaling).
4. Prior to and upon activation of TCI state of non-serving cell, actions performed by UE are unclear and needs discussion.
	* UE starts receiving UE-dedicated PDSCH, PDCCH from non serving cell
	* UE starts transmitting UE-dedicated PUSCH, and PUCCH to non serving cell

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| * [Issue 2] For Rel.17 NR FeMIMO, on L1/L2-centric inter-cell mobility:
	1. In RAN1#103-e, finalize scope and use cases for L1/L2-centric inter-cell mobility, including:
		+ Applicability in various non-CA and CA setups such as intra-band and inter-band CA
		+ Use cases in comparison to Rel.15 L3-based handover (HO) taking into account potential extension of DAPS-based Rel.16 mobility enhancement to FR2-FR2 HO
		+ The extent of RAN2 impact (MAC CE, RRC, user plane protocols)
		+ Network architecture, e.g. NSA vs. SA, inter-RAT scenarios
	2. In RAN1#103-e, depending on the outcome of 2a), further identify additional components –along with the associated alternatives –required for supporting inter-cell mobility based on the same unified TCI framework as that for intra-cell mobility (including dynamic TCI state update signaling), including
		+ Method(s) for incorporating non-serving cell information associated with TCI
		+ Method(s) for DL measurements and UE reporting (e.g. L1-RSRP) associated with non-serving cell(s)
		+ UE behavior for reception of signals and non-UE-specific control and data channels associated with non-serving cell(s)
		+ UL-related enhancements, e.g. related to RA procedure including TA
		+ Beam-level event-driven mechanism for L1/L2-centric inter-cell mobility
* FFS: The following enhancement scope is assumed by RAN1:
	1. Whether RRC reconfiguration signaling is needed or not when a TCI associated with non-serving cell RS is indicated
		+ A non-serving cell RS is an RS that is or has an SSB of a non-serving cell as direct or indirect QCL source
		+ This implies no C-RNTI update when UE receives DL channel RS associated to non-serving cell RS as QCL source.
		+ FFS whether TCI associated with non-serving cell can be indicated to or are applicable for all channels.
	2. Whether some RRC parameters need to be updated without additional RRC signaling, e.g. some RRC parameters are pre-configured, which are associated with TCI states with neighbor cell RS as QCL source
	3. Whether UE needs/can change serving cell during L1/L2-centric inter-cell mobility.
	4. The above assumption to be verified by RAN2
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## Serving cell change during L1/L2-centric inter-cell mobility

The grey area is the need of serving cell change during L1/L2-centric inter-cell mobility as RAN1 also indicated in cyan highlight below. One company contribution [5] explain the possible scenario which can be expected from the RAN1 agreements.



* Scenario 1: TCI state can be updated from TCI 1 associated with serving cell and TCI 2 associated with the non-serving cell. The UE is still in the coverage of serving cell.
* Scenario 2: TCI state is switched from TCI 1 associated with serving cell and TCI 3 associated to non-serving cell. Different from Scenario 1, the UE is not in the coverage of serving cell.

Meanwhile, some other companies think this serving cell change is not the mandated operation i.e. only if serving cell change is required to support above functionalities it can be introduced. Some companies also indicated that RAN2 TUs for feMIMO are not enough to introduce the complicated procedure and RAN2 should minimize the impact on this issue.

**Q1: What is the companies understanding on the required scope of the L1/L2-centric inter-cell mobility based on the RAN1 agreements and WID?**

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| **Company name** | **Scenario 1/ Scenario 2/ Both** | **Comments** |
| Nokia, Nokia Shanghai Bell | Both, but... | The scenarios listed above are not all scenarios: They completely ignore the dynamic of the case. We had some basic consideration for the procedures needed for the case in [8] (R2-2103639), which also relate to the scenario discussion - see the excerpted figure below.We would also note that scenario 1 can be just seen simply as the multi-TRP case discussed by RAN1 for Rel-16 already: UE is configured with additional CORESET pool or TCI state, it's just that in Rel-17 that can also come from different serving cell. Regardless, we think focus should be on the scenario 1 from above, but then what happens when UE moves from scenario 1 to Scenario 2 is all under RAN2 umbrella and needs discussion. That also ties into the question of how L3 mobility and the new L1/2 operation are used together. We think "serving cell change" is ambiguous in the RAN1 questions: Does it mean that L3 mobility is used (i.e. legacy case)? If it does, how does that work with the "non-serving cell addition/modification/change/release" when L1/2 mobility is used (i.e. Rel-17 scenarios)? This was also how we understood the RAN1 question: They are asking RAN2 to take a stance on how the two operations can be used together, but it's not so simple to answer that question without going into details.  |
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It is also true that RAN2 can first study all aspects to make answers on the questions from RAN1 LS in [2], otherwise RAN2 ask RAN1 to confirm what is the scope of the L1/L2-centric inter-cell mobility in terms of serving cell change.

**Q2: Do you think RAN2 needs to ask RAN1 on the scope of the L1/L2-centric inter-cell mobility in terms of serving cell change?**

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| **Company name** | **Yes/No** | **Comments**  |
| Nokia, Nokia Shanghai Bell | Yes but... | We should definitely ask as the LS was unclear in this (likely because RAN1 hadn't really thought it through yet), but RAN2 should point out that this depends heavily on whether the multi-TRP model is used: For example, without multi-TRP "serving cell change" likely means L3 mobility, but with multi-TRP, serving cell could perhaps remain. Hence, to make this clearer RAN2 could ask whether the L1/2 mobility is supposed to work 1) together with L3 mobility OR 2) separately from L3 mobility and whether this implies something for the multi-TRP operation? In our view we should separate the procedures for L1/2 and L3 mobility since the legacy L3 mobility has to be possible still (as it is the legacy procedure). We also think it would be useful to at least consider whether we can reuse the Rel-16 multi-TRP model as that could reduce RAN2 efforts.So how to ask the question and what information to give to RAN1 is crucial here - it's very clear there are a lot of details to handle even with the very basic operation, so indicating that to RAN1 is important to avoid having overly ambitious scenarios. |
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## RAN2 impacts on L1/L2-centric inter-cell mobility

In this sub-clause, we want to treat the RAN2 impact to support L1/L2-centric inter-cell mobility in order to make answers for the questions from RAN1 LS [2].

UE measures reference signals corresponding to beams for non-serving cells, if the signal quality of that RS (beam) of the non-serving cell is better than those of the serving cell, the network can indicate to the UE to start using the beam corresponding to the non-serving cell. Here, this L1/L2 signaling could be either beam switching and HO command based on the scenarios.

For Scenario 1, this is just a beam switch, where the new beam happens to be on the non-serving cell but UE has to support DL reception/UL transmission from the serving cell as well as non-serving cell while connected to the serving cell.

For Scenario 2, UE should change the dedicated channels from the source cell to non-serving cell when UE receives L1/L2 centric mobility signalling.

Below questions are related to the serving cell issues and those can be further investigated to make answers. How to handle UE-dedicated configuration and common configuration (i.e. RACH, SIB/MIB, etc) would be considered.

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| **Question 1**: In regard of serving cell, 1. Is there a need for a UE to change a serving cell for DL reception from or UL transmission to another (non-serving) cell, at least on UE-dedicated PDSCH, PDCCH, PUSCH, and PUCCH?
2. If so, how can the addition, release or change of a non-serving cell for DL reception and/or UL transmission be done? For example, would any of such actions require L3 handover and/or selection/activation among pre-configured candidate cells from RAN2 perspective?
3. If so, how can the TCI states associated with the previous serving cell be handled?
4. If so, what is the impact on the system information reception by the UE?
5. If so, what is the impact on the RACH and PUCCH-related procedures and configurations?
6. If not, what is the impact on the applicable use cases? That is, in what scenarios can the UE be configured for DL reception from or UL transmission to another (non-serving) cell, at least on UE-dedicated PDSCH, PDCCH, PUSCH, and PUCCH, if the serving cell does not change?
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**Q3: Do companies have any further comments on “Question 1” including discussion points?**

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| Nokia, Nokia Shanghai Bell | We would like to make several points about these aspects:* **DL Resource usage** between "serving cell" and "non-serving cell" still requires that UE can receive both (more or less) simultaneously, but there are some obvious challenges in that. Hence, RAN2 should ask what are the real uses cases RAN1 would like to enable for the L1/L2 mobility.
* **UL resource usage** (especially in intra-frequency cases) can be tricky as was seen e.g. during DAPS work in Rel-16. Hence, RAN2 could request RAN1 to clarify how UL is expected to work for L1/L2 mobility.
* **RRC configuration** for the "non-serving cell" would still require the same information as serving cell requires for the corresponding PxxCH to be used. Hence, it's quite likely that the configuration size will be large for most typical cases.
* **TCI state handling** is done via MAC, so the reply could state that to have efficient TCI state handling, a single MAC entity is needed.
* **System information** reception should not be required from non-serving cell (similarly as in CA/DC) and dedicated signalling can be used to provide the necessary information to UE.

In summary, before providing final answers, RAN2 should indicate to RAN1 that the exact scenarios where this operation is aimed will impact these answers: If all possible cases are to be supported, it is likely that the workload will make this part of the work impossible to be completed within the allotted TUs for this WI in Rel-17. |
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RAN2 impact especially for configuration aspect to support L1/L2 centric mobility should be considered, in general RAN2 use RRC configuration to configure UE-dedicated configuration and it is clear that new RRC configuration for non-serving cell is required. In addition, dynamic signaling (MAC CE and/or DCI, potentially selecting pre-configured values) could be possible so it can be introduced if needed.

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| **Question 2**: In regard of RRC configuration, RAN1 is discussing whether to allow a UE to be configured for DL reception from or UL transmission to a non-serving cell on UE-dedicated PDSCH, PDCCH, PUSCH, and PUCCH. From RAN2 perspective1. Depending on the answer to question 1-1, what would be the impact of allowing the UE to transmit and/or receive on some or all of those channels and which RRC parameter(s) would need to be reconfigured for the UE?
2. Is it feasible to update some of the above RRC parameter(s) via dynamic signaling (e.g. MAC CE and/or DCI, potentially selecting pre-configured values) without any additional RRC reconfiguration signaling?
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**Q4: Do companies agree that RRC configuration would be required to configure the required non-serving cell configurations (e.g. UE-dedicated PDSCH, PDCCH, PUSCH, and PUCCH, common configurations, etc) by pre-configuration?**

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| **Company name** | **Yes/No** | **Comments** |
| Nokia, Nokia Shanghai Bell | Yes but... | We are not sure what "preconfiguration" means here: Is this now implicitly accepting all the complexity that comes up with having to handle multiple non-serving cells? We have seen all of this before and it's sensible to limit to the essentials in the first release. Otherwise there's a risk that what is specified in Rel-17 is both incomplete and needlessly complicated, making it difficult to implement and/or deploy the feature. Hence, it would be far simpler from RAN2 perspective if we only limit to a single non-serving cell in Rel-17 and do not specify "dynamic switching" between multiple those. Anyway a single "non-serving cell" would still contain multiple TCI resources, so the need to have multiple of those seems rather unnecessary. But all this relates to which use cases are being considered in RAN1 and the scope of what is possible to do.Finally, it is of course "feasible" to have dynamic switching in the long run, but ensuring that the baseline operation works in Rel-17 is important: Once a stable baseline is established, further functionality can be built on top of that in later releases. We really should learn from the past and first create a simple baseline (with few capabilities) before heavy optimizations: Otherwise we risk having a large set of very fragmented capabilities that are difficult to implement, test and deploy, which is why we think the Rel-17 scope should be made clear. |
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For C-RNTI handling, it's also not at all clear what is the motivation of taking away the per-cell C-RNTI assignment: C-RNTI is just the identifier used to address UE via PDCCH. In addition, it is also clear that each cell can have a C-RNTI i.e. C-RNTI for non-serving cell may be different to serving cell, but it can be assigned the same value by implementation.

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| **Question 3**: In regard of C-RNTI:1. Is there a need to assign a UE a separate C-RNTI for DL reception from and UL transmission to a non-serving cell, or can the same C-RNTI from the serving cell be reused, at least for transmission and reception on UE-dedicated PDSCH, PDCCH, PUSCH, and PUCCH?
2. In restricting the use of the same C-RNTI for serving and non-serving cells, what would be the impact in applicable use cases and/or required specification support, if any?
3. If separate C-RNTIs are considered necessary in some cases, for serving and non-serving cells, how would this be configured for UE, i.e. is RRC reconfiguration signaling or some other (dynamic) signaling needed for configuring the separate C-RNTI(s)?
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**Q5: Do companies agree that C-RNTI for non-serving cell may be different to serving cell, but it can be assigned the same value by implementation (e.g. intra-DU case)?**

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| **Company name** | **Yes/No** | **Comments** |
| Nokia, Nokia Shanghai Bell | Yes | Each serving cell configures its own resources and this should be retained. If we were to require same C-RNTI in both cells, that will make the feature less usable: Requiring network to tightly coordinate the resources just makes the feature less likely to be usable. Thus, UE would have one C-RNTI for serving cell and another one for the "non-serving cell". |
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It also seems reasonable to assume that, just like currently, UE would obtain the non-serving cell C-RNTI via either 1) random access (i.e. similar to initial connection setup) or 2) RRC configuration (i.e. similar to handover). While the RRC configuration option would seem most suitable here, it's still not clear what would be required for UE to access the non-serving cell, so the first option might also be feasible if UE would have both UL and DL towards the non-serving cell. But using RRC configuration (from target cell) should be the baseline.

**Q6: Do companies agree that RRC configuration (from target cell) should be the baseline for configuring the C-RNTI for non-serving cell?**

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| **Company name** | **Yes/No** | **Comments** |
| Nokia, Nokia Shanghai Bell | Yes | We think the entire "non-serving cell" configuration can be provided via RRC and that would also include the C-RNTI. |
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For CU/DU split question, it is related to we restrict the L1/L2 centric mobility for some cases (e.g. intra-DU deployment). Some companies proposed to restrict this feature only for intra-DU case in order to reduce the complexity of the Rel-17 work. Meanwhile, other companies proposed to apply this feature for general deployment scenarios including inter-DU deployment because complexity is not the critical reason to object the general support of the feature.

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| **Question 4**: In regard of CU-DU split, from RAN2/3 perspective, is there any difference between supporting intra-DU only and supporting inter- in addition to intra-DU, in terms of the following? 1. The associated RAN2 specification impact,
2. Applicable use cases (e.g. deployment scenarios), and
3. Network inter-operability (e.g. across different gNB vendors)
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**Q7: Do companies agree that restriction of deployment scenario only for intra-DU is needed? What RAN2 specification impact would be concerned?**

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| **Company name** | **Yes/No** | **Comments** |
| Nokia, Nokia Shanghai Bell | Yes | Since the MAC configuration is contained within on DU, doing inter-DU would require different approach for the RRC configuration itself. Supporting inter-DU might also imply different CU-UP, which would complicate CU handling. And even if we restrict to only one CU-UP and CU-CP, that would both require extra inter-node signalling but also significant changes in RAN2 configuration, so it would be simpler to limit to intra-DU cases. |
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According to the companies contributions, companies think the RAN2 impact on CA and RF impacts of L1/L2 mobility is quite limited i.e. only UE capability issues will be expected. RAN1 seem to support intra-frequency scenarios (i.e. serving and non-serving cells share the same SSB frequency) but inter-frequency cases (i.e. serving and non-serving cells have different SSB frequency) bring some more issues (e.g. measurement gaps, UE capabilities, etc). In addition, many companies provided the comments that the decision/answer to support intra- and inter- frequency is up to RAN4.

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| **Question 5**: In regard of CA issues, RAN1 is discussing whether the operation is supported only for intra-band CA scenario (i.e. UE is configured to operate with serving and non-serving cells that belong to the same frequency band) or for both intra-band CA and inter-band CA scenarios. Note that one common TCI state ID associated with a non-serving cell, if supported, may be optionally applied for CCs in a band.1. Are there specific RAN2/4 issues (including higher-layer impact) that need to be considered for deciding between the two alternatives?

**Question 6**: In regard of inter-frequency issues, from RAN2/4 perspective, what would be the higher-layer and RRM impact assuming inter-frequency scenarios as opposed to intra-frequency scenarios? For intra-frequency scenario, it is assumed that SSBs of non-serving cells have the same center frequency and SCS as the SSBs of the serving cell.* Note: RAN1 has agreed to support intra-frequency scenarios, whereas the support for inter-frequency scenarios is still for further study.
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**Q8: What do you think about supporting intra- and inter- frequency issues?**

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| **Company name** | **Intra-freq/ Inter-freq/ Up to RAN4** | **Comments** |
| Nokia, Nokia Shanghai Bell | At least Intra-freq but Up to RAN4 | This depends heavily on the envisioned use case: Since the work is done under "fast beam management", it seems targeted towards intra-frequency. Similarly, since it's even called "L1/L2-centric inter-cell **mobility**", this implies it would be working with similar cases as mobility, for which intra-frequency is the most useful case. So this question also ties to the question on expected use cases and scenarios - RAN1 should provide more information on those, and RAN4 should evaluate what is possible based on those. |
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**Q9: Do companies have any further issues to be discussed here?**

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| **Company name** | **Comments** |
| Nokia, Nokia Shanghai Bell | So far it seems the terminology for this feature is rather confusing so RAN2 could be proactive and define the terminology for this topic, including the used acronym (e.g. "Seamless beam switch (SBS)", "Lower Layer Mobility (LLM)" or something similar). This could help also RAN1 and RAN2 tends to anyway view the overall functionality more so is in better position to consider such aspects.  |
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# Conclusion

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# Reference

1. R2-2102625 LS on Agreements Pertaining to L1/L2-Centric Inter-Cell Mobility (R1-2102209; contact: Samsung) RAN1 LS in Rel-17 NR\_feMIMO-Core To:RAN2 Cc:RAN3, RAN4
2. R2-2102627 LS on TCI State Update for L1/L2-Centric Inter-Cell Mobility (R1-2102248; contact: Samsung) RAN1 LS in Rel-16 NR\_feMIMO-Core To:RAN2, RAN3, RAN4 Cc:RAN
3. R2-2103330 Considerations on L1/L2 centric inter-cell mobility Samsung discussion Rel-17 TEI17 DISCUSSION
4. R2-2102855 Discussion on L1 L2-Centric Inter-Cell Mobility vivo discussion Rel-17 NR\_feMIMO-Core
5. R2-2102870 Discussion on L1/L2-Centric Inter-Cell Mobility Intel Corporation discussion Rel-17 NR\_feMIMO-Core
6. R2-2103079 Discussion on L1/L2 Mobility Qualcomm Incorporated discussion
7. R2-2103260 RAN2 Impacts of L1L2-Centric Inter-Cell Mobility MediaTek Inc. discussion
8. R2-2103639 Discussion on RAN1 LS for L1/L2-Centric Inter-Cell Mobility Nokia, Nokia Shanghai Bell discussion Rel-17 NR\_feMIMO-Core
9. R2-2103823 On RAN1 LS (R2-21xxxxx) for L1/L2 centric inter-cell mobility Ericsson discussion
10. R2-2103866 L1/L2-centric inter-cell mobility Apple discussion Rel-17 NR\_feMIMO-Core
11. R2-2104116 RAN2 impact of L1/L2 centric mobility and inter-cell multi-TRP Huawei, HiSilicon discussion
12. R2-2103341 DRAFT LS Reply on TCI State Update for L1/L2-Centric Inter-Cell Mobility Samsung LS out Rel-17 TEI17 To:RAN1 Cc:RAN3, RAN4
13. R2-2103673 Draft Reply LS on TCI State Update for L1/L2-Centric Inter-Cell Mobility Nokia, Nokia Shanghai Bell LS out Rel-17 NR\_feMIMO-Core To:RAN1 Cc:RAN3, RAN4, RAN