**3GPP TSG RAN WG1 Meeting #110bis-e R1-22xxxxx**

**e-Meeting, October 10th – 19th, 2022**

**Source: Moderator (Fujitsu)**

**Title: FL summary 1 on L1 enhancements for inter-cell beam management**

**Agenda Item: 9.12.1**

**Document for: Information**

# Introduction

In this contribution, we share our view on the work area of L1 enhancements for inter-cell beam management, which includes L1 measurement and reporting, beam indication, and dynamic switch mechanism among candidate serving cells (including SpCell and SCell) [1].

# Plan for discussion

[110bis-e-R18-Mobility-01] Email discussion on L1 enhancements for inter-cell beam management by October 19 – TBD (TBD)

* To be kicked off after first GTW session
* Check points: October 14, October 19



1st deadline: October 11, 23:59am UTC 🡪 Updated FL proposals will be provided

Intermediate deadline: October 12, 10:59am UTC 🡪 Selected proposals will be discussed in the Wed GTW session

* GTW topic will be chosen from section 5.1.X and 5.2.X considering the maturity of the discussion
	+ High priority for proposals 1-1, 1-4, 1-5, 2-1
	+ Other proposal will be treated on a best effort basis.

2nd deadline: October 13, 23:59am UTC 🡪 Updated FL proposal will be provided for the 1st checkpoint (October 14th)

FFS after the 1st checkpoint

# Contact Person

Please input the contact information for each company below:

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| Company | Name  | Email  |
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# List of Contributions

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| [**R1-2208406**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208406.zip) | L1 enhancements for inter-cell beam management | Huawei, HiSilicon |
| [**R1-2208500**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208500.zip) | Discussion on L1 enhancements for L1/L2-based inter-cell mobility | Nokia, Nokia Shanghai Bell |
| [**R1-2208509**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208509.zip) | L1 enhancements for inter-cell beam management | ZTE |
| [**R1-2208570**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208570.zip) | Discussion on L1 enhancements for inter-cell beam management | Spreadtrum Communications |
| [**R1-2208664**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208664.zip) | Discussion on L1 enhancements for L1/L2 mobility | vivo |
| [**R1-2208679**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208679.zip) | L1 enhancements to inter-cell beam management | Ericsson |
| [**R1-2208747**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208747.zip) | L1 enhancements for inter-cell beam management | Lenovo |
| [**R1-2208805**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208805.zip) | Discussions on Inter-cell beam management enhancement | OPPO |
| [**R1-2208884**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208884.zip) | On Intercell beam management enhancement for NR mobility enhancement | Google |
| [**R1-2208905**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208905.zip) | Enhancements on inter-cell beam management for mobility | LG Electronics |
| [**R1-2208958**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208958.zip) | On L1 enhancements for inter-cell beam management | CATT |
| [**R1-2209024**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209024.zip) | Views on L1 enhancements for inter-cell beam management | Fujitsu |
| [**R1-2209073**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209073.zip) | L1 Enhancements for Inter-cell Beam Management | Intel Corporation |
| [**R1-2209203**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209203.zip) | L1 enhancements for inter-cell beam management | InterDigital, Inc. |
| [**R1-2209268**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209268.zip) | Discussion on L1 enhancements and Dynamic switch mechanism | xiaomi |
| [**R1-2209359**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209359.zip) | Discussion on L1 enhancements for inter-cell beam management | CMCC |
| [**R1-2209428**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209428.zip) | Discussion on L1 enhancements for inter-cell beam management | NEC |
| [**R1-2209498**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209498.zip) | L1 enhancements for inter-cell beam management | MediaTek Inc. |
| [**R1-2209603**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209603.zip) | On L1 enhancements for inter-cell mobility | Apple |
| [**R1-2209754**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209754.zip) | On L1 enhancements for inter-cell beam management | Samsung |
| [**R1-2209923**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209923.zip) | Discussion on L1 enhancements for inter-cell mobility | NTT DOCOMO, INC. |
| [**R1-2210008**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210008.zip) | L1 Enhancements for Inter-Cell Beam Management | Qualcomm Incorporated |

# Discussion

## L1 measurement

### Intra-frequency L1 measurement

##### [Summary of contributions]

* Even though it is not always explicitly proposed by companies to support intra-frequency L1 measurement, it is deemed that many companies assumed that intra-frequency L1 measurement is supported for Rel-18 L1/L2 mobility.
	+ Some companies clearly mentioned that Rel-17 L1 measurement (i.e. *CSI-SSB-ResourceSet*) is a starting point, which includes intra-frequency L1 measurement.
* Meanwhile, it is also mentioned that the mechanism of intra-frequency measurement is not necessarily follow Rel-17 ICBM mechanism because RAN2 has agreed that Rel-17 ICBM is not a prerequisite feature for L1/L2 mobility, i.e. commonality with inter-frequency measurement is important.
* Furthermore, potential issues below are raised to support Rel-18 L/L2 mobility scenarios, which require more discussion in RAN1. It is noted that this requires additional RAN4 work.
	+ Restriction on Rel-17 L1 intra-frequency measurement is still valid or not, e.g.
		- The same SCS and *sfn-SSB-Offset* as the serving cell
		- The same center frequency as the SSB of the serving cell
		- Rx time difference, i.e. SSB from non-serving cell should be received within the CP of that for serving cell
			* This may require symbol level L1 measurement gap or SMTC for asynchronous cells
		- Measurement for overlapping SSBs

##### [FL observation]

Given the majority view, FL thinks that intra-frequency non-serving cell L1 measurement should be supported for Rel-18 L1/L2 mobility, and this can be agreed in this meeting. Meanwhile, further discussion is needed whether Rel-17 mechanism for ICBM can be reused, modification is necessary or new mechanism is more suitable to support Rel-18 scenarios. FL proposal would like to request interested companies to further study what is the best design for intra-frequency L1 measurement until the next RAN1 meeting taking into account the proposals from companies:

##### [FL proposal 1-1-v1]

* For Rel-18 L1/L2 mobility, intra-frequency non-serving cell L1 measurement is supported
	+ At least the following aspects are for RAN1 further study:
		- Possibility to reuse of Rel-17 ICBM CSI measurement framework
		- Relaxation for the restrictions imposed on the Rel-17 intra-frequency L1 non-serving cell measurement, where RAN4 impact is foreseen, i.e.
			* SCS alignment with serving cell
			* Center frequency alignment and/or SFN offset compared with serving cell
			* BWP setting, i.e. non-serving cell SSB should be covered by serving cell active BWP
			* Introduction of symbol level gap or SMTC for larger Rx timing difference (i.e. larger than CP length)
		- Commonality with inter-frequency L1 measurement (if supported)
* *FL note: this issue is a high priority issue from FL point of view*

##### [Discussion on proposal 1-1-v1]

Please input your view in the table below:

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### Inter-frequency L1 measurement

##### [Summary of contributions]

* Although the discussion on inter-frequency measurement is ongoing in RAN2, many companies showed their interest on the support of inter-frequency L1 measurement, which is required for inter-cell mobility scenario captured in the WID.
* It is also pointed out by many companies that the introduction of SMTC and measurement gap would be needed to perform inter-frequency L1 measurement.
* The definition of inter-frequency scenario is however not clear, and hence the clear distinction of intra-frequency and inter-frequency is needed, which may require RAN4’s help.
	+ For example, even when the frequency of non-serving cell SSB is the same as serving cell SSB, it might be categorized as inter-frequency if the SCS not identical.
* It is proposed to use CSI-RS based measurement and reporting for inter-frequency (and this will be discussed in section 5.1.4)

##### [FL observation]

FL thinks that the scenario discussions should be done in RAN2 although spec impact should be analysed in RAN1 and RAN4. Given the situation that RAN2 discussion on inter-frequency mobility is still ongoing, RAN1 should wait for their input to avoid the duplicated discussion. Therefore, FL would propose to focus only on the potential RAN1 spec impact at this moment, and the detailed discussion can be started after receiving RAN2 LS.

##### [FL proposal 1-2-v1]

* For Rel-18 L1/L2 mobility, further study the potential RAN1 spec impact of inter-frequency L1 measurement
	+ At least the following aspects are considered:
		- Introduction of measurement gap and SMTC for L1 inter-frequency measurement
		- Commonality with L1 intra-frequency measurement for measurement configuration
	+ The definition of inter-frequency includes at least:
		- the frequency of the measured RS is not covered by any of the active BWPs of SpCell and Scells configured for a UE.
	+ The decision on the introduction of inter-frequency L1 measurement is up to RAN2
* *FL note: this issue is a high priority issue from FL point of view, but RAN1 should wait for the decision by RAN2*

##### [Discussion on proposal 1-2-v1]

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### Support of L3 measurement

##### [Summary of contributions]

* It is proposed by one company to reuse L3 measurement mechanism for neighbour cell detection in L1/L2 based mobility.

##### [FL observation]

This issue has been discussed in RAN2 and captured as FFS in their minute. Duplicated discussion among WGs should be avoided.

##### [FL proposal 1-3-v1]

* RAN1 will not discuss the necessity of L3 measurement for L1/L2 mobility unless explicit request from RAN2 is received.
* *FL note: It is not intended that this proposal is captured in Chair’s note.*
* *FL note: this issue is a low priority issue from FL point of view.*

##### [Discussion on proposal 1-3-v1]

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### Measurement RS

##### [Summary of contributions]

* It seems that most of the companies (all the companies?) think SSB should be used for L1 measurement for Rel-18 L1/L2 mobility.
* In addition, many companies have a view that CSI-RS based non-serving cell L1 measurement should be supported to enables larger bandwidth with short period, or to obtaining new refined beams for latency reduction.
	+ This is to introduce explicit configuration for neighbour cell measurement, i.e. proponent companies do not want to mimic as if non-serving cell RS comes from the serving cell.
	+ Also, it is also proposed to use CSI-RS for tracking, CSI-RS for beam management QCLed with SSB associated with non-serving cell for non-serving cell L1 measurement.

##### [FL observation]

While SSB can be a baseline for non-serving cell L1 measurement, use of CSI-RS for non-serving cell L1 measurement can be further discussed in RAN1 given the companies’ interest and potential benefits. The potential discussion includes the necessity itself, and how the configuration is performed. It is noted that the introduction of CSI-RS L1 measurement requires RAN4 to specify it’s requirements.

##### [FL proposal 1-4-v1]

* For Rel-18 L1/L2 mobility, SSB is supported for intra-frequency L1 measurement
* Further study the following for non-serving cell L1 measurement RS
	+ SSB for inter-frequency (if supported)
	+ CSI-RS associated with non-serving cell PCI, i.e. *additionalPCI*, for intra-frequency and inter-frequency (if supported)
* *FL note: this issue is a high priority issue (at least for SSB) from FL point of view. On the other hand, the use of CSI-RS looks an optional feature and an optimization, and FL doesn’t recommend spending much time.*

##### [Discussion on proposal 1-4-v1]

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### Measurement quantity

##### [Summary of contributions]

* It seems that most of the companies (all the companies?) think L1-RSRP should be used for Rel-18 L1/L2 mobility.
* L1-SINR is also proposed to measure interference situation and more flexible target cell selection.
* Furthermore, use of UL measurement is proposed to avoid delay and computation complexity at a UE.

##### [FL observation]

Along with the majority companies view, L1-RSRP should be used for L1 measurement for Rel-18 L1/L2 mobility. In addition, introduction of L1-SINR for non-serving cell measurement need further discussion because only a limited number of companies mentioned about the necessity in their contribuions. In addition, UL measurement may be useful for Rel-18 L1/L2 mobility, even though the details are not clear at this moment. Companies are encouraged to further study the benefit, drawback and RAN1 spec impact.

##### [FL proposal 1-5-v1]

* For non-serving cell measurement for Rel-18 L1/L2 mobility,
	+ L1-RSRP is supported for intra-frequency non-serving cell measurement.
	+ Further study the following measurement quantities for non-serving cell measurement
		- L1-RSRP for inter-frequency (if supported)
		- L1-SINR for intra-frequency and inter-frequency (if supported)
		- UL measurement for intra-frequency (and inter-frequency, feasibility should be further assessed)
* *FL note: this issue is a high priority issue (at least for RSRP) from FL point of view. Not sure of other quantity, thus companies’ input is appreciated.*

##### [Discussion on proposal 1-5-v1]

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### Filtering for L1 measurement results

##### [Summary of contributions]

* Many companies see the necessity of filtering for mobility robustness, i.e. avoiding ping-pong, avoiding large amount of measurement results for gNB, or relaxing the negative impact by UE rotation.
* Two types of filtering are proposed at this meeting:
	+ L3 filtering (in time domain):
	+ cell-level filtering (in spatial domain), which includes the averaging of best X beams in a cell

##### [FL observation]

While the interest by many companies on filtering, the importance of “ping-pong avoidance” has not been confirmed in RAN2. Hence, the decision on ping-pong should be concluded in RAN2 first, and then RAN1 can decide which way to go. FL recommendation is to wait for RAN2 LS and then to make RAN1 decision whether or not filtering is applied to L1 measurement results. Until then, RAN1 can discuss the potential definition of filtering and applicability of L1 measurement quantities.

##### [FL proposal 1-6-v1]

* For Rel-18 L1/L2 mobility, further study the necessity of filtering to L1 measurement results considering at least the following aspects:
	+ Exact definition of filtering
		- L3 filtering (in time domain): e.g. exact definition of time domain filtering
		- Cell-level measurement (in spatial domain): e.g. how many beams are averaged, and/or how the beams are chosen.
	+ Importance to avoid ping-pong handover for L1/L2 mobility
		- Alignment with RAN2 is expected
	+ Impact of UE rotation
	+ Applicability to L1-RSRP and L1-SINR (if supported)
	+ Applicability to intra-frequency and inter-frequency (if supported)
* *FL note: this issue is a medium priority issue, the system will work without this functionality even though it is not optimum. Thus FL recommends not to spending much time on this issue and make our decision at an early stage of Rel-18.*

##### [Discussion on proposal 1-6-v1]

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### Configurations for L1 measurement

##### [Summary of contributions]

* Due to the support of multi-beam/multi-frequency/multi-cell measurements under Rel-18 L1/L2 mobility scenarios, it is required for gNB and UE to handle large amount of measurement (and configuration) in order to find the best beam/cell for mobility. Thus, it is questioned that the number of cells/RSs need to be extended from Rel-17 ICBM.
	+ Change the maximum number of additional cells (i.e. non-serving cells)
	+ Change the maximum number of RSs associated with each cell that can be configured for L1 measurement
	+ Note that if nothing is changed, gNB may be required to perform RRC reconfiguration
* On the other hand, companies also see the necessity to enhance the configuration on L1 measurement to avoid the complication at a gNB, and memory requirement for a UE, e.g.
	+ The beam measurements for L1/L2 mobility should require only a minimum of configuration, i.e.
		- Similar approach as L3 measurement: the L3 measurements only require a target frequency, and intra-frequency L3 measurements do not require any configuration at all. In particular, the UE does not need to be informed which PCIs it should measure: the UE finds the SSBs of any relevant PCI without explicit configuration
	+ Use MAC CE to activate/deactivate the measurement of reference signals for a cell or the measurement PCIs, and reporting set may also be updated due to this activation.
	+ Possibility to reuse pre-configuration for target cell(s), which may include RRC parameters for measurement RS and TCI states
* Furthermore, it is pointed out that the commonality between intra-DU and inter-DU case, where obtaining full RRC configuration for the target cells is not undesirable.

##### [FL observation]

It would be straightfoward to consider to the extention of configured nubmer of PCIs and RSs becuase a UE is required to measure more number of beams for non-serving cells in order to find the best beam/cell for handover. However, there is a trade-off relationship between performance and complexity. Therefore, it is resonable for RAN1 to closely look at this issue, and FL would propose RAN1 to further study this issue, and to find a well-balanced system design on this matter.

##### [FL proposal 1-7-v1]

* For Rel-18 L1/L2 mobility, further study at least the following aspects for the configuration of L1 measurement:
	+ Whether to change the maximum number of additional cells (i.e., non-serving cells), which is 7 for Rel-17 ICBM
		- this includes the concept not to indicate any PCIs for L1 measurement
	+ Whether to change the maximum number of RSs associated with each cell that can be configured for L1 measurement, which is 64 for Rel-17 ICBM
		- this includes the concept not to indicate any RSs for L1 measurement
	+ Whether to introduce enhancements for L1 measurement to avoid a large amount of active measurement configurations or frequent reconfiguration.
	+ Whether and how to communize the configuration for intra- and inter-DU case.
* *FL note: this issue is a medium priority issue; the system may work without this functionality even though it is not optimum. It would be good for RAN1 to better understand the problem first.*

##### [Discussion on proposal 1-7-v1]

Please input your view in the table below:

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## L1 measurement reporting

##### [Summary of contributions]

* According to the submitted contributions that many companies have an understanding that the gNB triggered/configured reporting, which is supported for Rel-17 ICBM, can be reused for Rel-18 L1/L2 mobility
	+ Periodic, semi-persistent and aperiodic L1 measurement reporting using reference signals associated with non-serving cell PCI
	+ Reuse the reporting format for Rel-17 ICBM, i.e. 4 beams can be reported in a report instance, including serving cell and non-serving cell, where absolute 7-bit RSRP and remaining 4-bit differential RSRP value relative to the absolute value
	+ Also, there are discussions about the reporting format to support Rel-18 scenarios
		- Frequency indicator if inter-frequency L1 measurement is supported.
		- Support of more than 4 beams in a report instance.
		- Support of reporting a variable number of SSBRI/RSRP pairs, wherein a UE reports in a single reporting instance a two-part beam report using the Rel-15 two-part UCI. The 1st part has fixed payload size while the 2nd part is used to report the remaining information.
		- Support reporting for top N candidate cells with cell-level filtered measurement results.
* On the other hand, L1 measurement report using MAC CE is also proposed to enable large size of reports, and to achieve more reliability.
* In addition, many companies propose to introduce UE /event triggered report (which was discussed in Rel-17 ICBM but not agreed) to reduce reporting overhead and UE power consumption while it is claimed that the motivation of event triggered L1 reporting is not clear.
	+ Nevertheless, companies have quite different understanding on the detailed design: i.e. triggering event (reuse of L3 event, or new event, etc.), resources allocation/request used for reporting, indication to gNB if the condition is met (using SR or MAC CE), how to start or stop the report (timer base), how the target RS and PCI is configured, necessity of TTT (Time To Trigger) and/or contents of the beam report etc.

##### [FL observation]

There are small number of proposals on L1 measurement report in this meeting. Some companies propose to reuse the mechanism for Rel-17 ICBM (i.e. reporting format). On top of that, some also see the necessity to enhance it to support Rel-18 scenarios (such as inter-frequency handover which may result in large number of measurement and report). Another idea to cope with Rel-18 scenario is to use MAC CE to enable large amount of L1 measurement report with higher reliability.

Event/UE triggered report was proposed by many companies, similarly to Rel-17. While this technique is well-known in RAN1 for a long time, it seems companies still have quite different views on the details design of UE /event triggered report (despite the simple name, unfortunately). This situation prevents FL from coming up with concrete options for UE /event triggered report (i.e. option 1, option 2 ~~) for down selection because tons of combinations can be considered. Therefore, FL would like to propose two phase approach, i.e. (1) summarize and agree the discussion points at this meeting, and (2) discuss and decide if event/UE triggered report is supported or not, and agree the limited number of options for further discussion at RAN1#111. Spending much time on this issue is not recommended.

##### [FL proposal 2-1-v1]

* For L1 measurement report for Rel-18 L1/L2 mobility, further study the following mechanisms:
	+ Report as UCI on PUCCH or PUSCH
		- Periodic report on PUCCH, semi-persistent report on PUSCH and aperiodic report on PUSCH
		- Reuse the report format defined for Rel-17 ICBM, and further study the enhancements to accommodate Rel-18 scenarios, e.g.
			* Inter-frequency measurement, if supported
			* Increasing the maximum number of reporting beams, which is 4 for Rel-17 ICBM
			* Reducing the reporting overhead by e.g. choosing N-best beams/cells
	+ Report on MAC CE
* For L1 measurement report for Rel-18 L1/L2 mobility, interested companies are encouraged to further study the necessity of UE/event triggered report for L1 measurement results and the detailed design until RAN1#111
	+ At least the following aspects should be considered in the companies’ proposal
		- Exact definition of events, i.e. events defined for L3 measurement report, or something new
		- Report container i.e. UCI transmitted on PUCCH or PUSCH and/or MAC CE etc.
		- Resource allocation/assignment for UE/event triggered report i.e. resource is allocated in advance, requested when the event is met, and/or activated when the condition is met etc.
		- Necessity of indication to gNB when the condition is met, and how
		- Necessity to define the condition to start/stop the reporting, e.g. timer
		- Necessity of time to trigger
		- Contents of the report/reporting format, PCI, RS ID, measurement result etc.
* *FL note: this issue is a high priority issue; at least one container shall be defined. On the other hand, UE event triggered report look like an optimization. Thus FL doesn’t recommend spending much time on this issue.*

##### [Discussion on proposal 2-1-v1]

Please input your view in the table below:

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## Beam indication

### Beam indication mechanism:

##### [Summary of contributions]

* Many companies think the beam indication at target cell(s) (this includes SpCell and SCell(s) as agreed in RAN2) is performed based on Rel-17 TCI framework (Option. A below). Meanwhile, it is also pointed out that Rel-15 TCI framework (Option. B below) needs to be considered if Rel-17 TCI framework cannot be a prerequisite for Rel-18 L1/L2 mobility.
	+ **Option A:** Beam indication for Rel-18 L1/L2 mobility is designed based on Rel-17 TCI framework mechanism
		- RRC configurations of DL/UL/joint TCI states for potential target cell(s) are activated by MAC CE, and indicated by DCI
		- Potential issues pointed out by companies
			* Coexistence with Rel-17 inter-cell beam mTRP
			* Support of CA, i.e. how to perform beam indication for multiple cells
			* Handling of common-PDCCH (which cannot be switched to non-serving cell in Rel-17)
			* How and whether the list of TCI states associated with target cell(s) is/can be configured, including whether the TCI states for target cell(s) are availble or not
			* Application time for new beam activation need to be updated compared with Rel-17 ICBM.
	+ **Option B:** Beam indication for Rel-18 L1/L2 mobility is designed based on Rel-15 TCI framework mechanism
		- TCI indication is valid only for a certain channel, and update by RRC reconfiguration is required to update QCL/Tx spatial filter/pathloss reference.
		- Detailed mechanism and potential issues need further discussion (i.e. the details are not discussed by the contributions submitted to this meeting)
* Alt.1 and Alt.2 may or may not be exclusive to each other. Choosing Option A only (i.e. Rel-17 TCI framework as baseline) will make the specification simpler, but Choosing Option A+B will make the deployment and implementation (at least for network side) easier resulting in earlier market introduction.
* There is a proposal that discussion on potential L1 signaling design and enhancements on L1 measurement/reporting related to dynamic serving cell switch should be deprioritized till further RAN2 inputs are provided.

##### [FL observation]

While many companies assume Rel-17 TCI framework can be the baseline for Rel-18 L1/L2 mobility, it should be firstly decided if Rel-18 L1/L2 mobility should assume a specific TCI framework, i.e. whether Rel-15 TCI framework need to be considered. FL thinks the decision on this matter is very important for this WI because it has a big impact for the whole design of Rel-18 L1/L2 mobility. As already indicated by RAN2 LS, prerequisite discussion has already happened in RAN2 and the same situation is expected for TCI framework assumption. In this sense, FL believes the RAN1 discussion should be hold a bit until RAN2 concludes their discussion. Note that FL confirmed that a RAN2 contribution bringing up this issue is submitted to RAN2#119b-e, and hence no LS from RAN1 would be necessary.

##### [FL proposal 3-1-v1]

* RAN1 to further study if the beam indication of target cell(s) L1/L2 mobility should be designed for a specific TCI framework, e.g. Rel-17 unified TCI, and their potential spec impact. RAN1 discussion will be commenced after receiving RAN2 LS.
* Interested companies are encouraged to work with their RAN2 colleagues to accelerate the discussion.
* *FL note: FL doesn’t see a strong necessity to make any agreement/conclusion for this proposal at this meeting while some email discussion is expected in this meeting. The result of the email discussion will be used as a reference for RAN1#111.*
* *FL note: this issue is a high priority issue.*

##### [Discussion on proposal 3-1-v1]

Please input your view in the table below:

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### Timing of beam indication:

##### [Summary of contributions]

* Many companies assume that the beam indication for the target cell(s) comes together with L1/L2 cell switch command. Meanwhile, it is also proposed that the beam indication can be performed before the command is received. These mechanisms are useful to reduce the handover latency due to the beam search procedure.
* Also, the necessity of beam indication after L1/L2 mobility command is also discussed in the case where L1 measurement results for target cells are not available when the command is sent. For example, support of cell level L1 measurement and the use of L3 measurement are also proposed and if so, it is not clear if the gNB has a sufficient information which beam is the best for a UE. In this case, the beam indication at the target cell(s) may be performed after the handover command is sent out (i.e. target cell is determined but exact beam is not determined). However, it is not clear at this moment if this is a valid scenario.

##### [FL observation]

RAN2 is now discussing the time chart after enhancement, and timing of beam indication is an open issue. Hence, RAN2 view is important to make the final decision at RAN1 on the timing of beam indication. Given this situation, RAN1 should not have any specific assumption on the timing of beam indication at this moment, and the detailed discussion can be started after receiving RAN2 LS. RAN1 can keep the following 3 scenarios below for now, and FL would encourage interested companies to further study the validity of the scenarios and potential RAN1 spec impacts until then.

* Scenario 1: Beam indication before command
* Scenario 2: Beam indication together with command
* Scenario 3: Beam indication after command

##### [FL proposal 3-2-v1]

* From RAN1 perspective, the following scenarios can be considered for Rel-18 L1/L2 mobility for beam indication timing. This will be updated depending on RAN2 decision on the time chart
	+ Scenario 1: Beam indication before command
		- This scenario happens when, e.g. Rel-17 ICBM is enabled before receiving handover command.
	+ Scenario 2: Beam indication together with command
		- This scenario happens when, e.g. the best/appropriate beam for a UE is known to the source cell when the commend is sent to the UE.
	+ Scenario 3: Beam indication after command
		- This scenario happens when, e.g. the best/appropriate beam for a UE is not known to the source cell when the L1/L2 mobility command is sent to the UE
* Interested companies are encouraged to further study the validity of the scenarios and the potential spec impact.
* *FL note: FL doesn’t see a strong necessity to make any agreement/conclusion for this proposal at this meeting while some email discussion is expected in this meeting. The result of the email discussion will be used as a reference for RAN1#111.*
* *FL note: this issue is a high priority issue*

##### [Discussion on proposal 3-2-v1]

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## Cell switch command

##### [Summary of contributions]

* A number of companies proposed the signaling details on cell switch command, and DCI and MAC CE are proposed to carry L1/L2 cell switch command. It is pointed out that RAN1 spec impact is clearly foreseen if DCI is chosen as cell switching command.
* The proponents of DCI think the design would be an extension of Rel-17 unified TCI (activated by MAC CE plus indicated by DCI), and at least the following aspects need to be considered to fit L1/L2 mobility:
	+ Incorrect detection of command, then acknowledgement is necessary. FL notes that RAN2 is more appropriate place to discuss if the intention is handover complete message,
	+ Configuration and activation of the TCI states for non-serving cells
	+ Update of TCI state (QCL RSs) after cell switch
* Meanwhile, there are multiple companies who is supportive for MAC CE due to the following reasons:
	+ Better flexibility to extend the capacity to carry more necessary information.
	+ It is still challenging to carry at least the identity of target cell and TCI state to be applied in target cell by re-purposing fields in current DCI format.
* When making the decision on the mechanism, it is proposed to consider the following aspects/scenarios, i.e. the design of L1/L2 cell switch command should be common (as much as possible) irrespective of the scenarios below:
	+ Support of inter-/intra-DU, inter/intra-frequency scenario
	+ Whether the command will trigger DL sync, UL sync and/or beam indication at a target cell as well as cell switch
* Additionally, UE autonomous triggering of cell switch (a.k.a. UE-initiated dynamic cell switch) is also proposed by some companies, which has not been discussed in RAN2 yet. The mechanism is e.g.
	+ The UE can indicate a handover request in its measurement report. The cell-switch can be triggered once the measurement report is received by the network.
* Some companies have performed their analyses on the necessary information included in L1/L2 cell switch command. The following is the summary of the information proposed by companies:
	+ cell/cell group ID for target cell/cell group
	+ SSB Index
	+ TCI state for the target cell
	+ pointer to a target configuration
	+ QCL source (or QCL source switching) for DL reception
	+ TA value for the target cell.
	+ BWP ID for DL and UL for target cells
	+ Activation information of CSI-RS resource setting and CSI reporting
	+ Random Access Preamble Index, PRACH Mask Index
	+ Handover flag (to differentiate Rel-17 inter-cell mTRP and Rel-18 L1/L2 mobility)
	+ Triggering of DL/UL synchronization
* It is noted that one company proposes to that discussion on potential L1 signaling design and enhancements on L1 measurement/reporting related to dynamic serving cell switch should be deprioritized till further RAN2 inputs are provided.

##### [FL observation]

Even though some RAN1 spec impact is foreseen (especially when DCI is selected), FL thinks that this is a RAN2 driven issue and duplicated discussion in RAN1 should be avoided. Thus, FL proposal is to hold the discussion in RAN1 until we receive a RAN2 LS to request RAN1 work. What RAN1 should/can do for now is to perform a technical analysis on the pros/cons for DCI/MAC CE based activation from RAN1 perspective, and to list the necessary information included in the command from RAN1 perspective, which would be useful for RAN2 decision.

Regarding the contents of handover command, it looks that the contents proposed in this meeting are fundamental information of “mobility”, which should be handled by RAN2. FL recommendation is to firstly list the “RAN1 relevant” information, and then to send it to RAN2 as necessary. Then RAN2 will make the decision on the container of L1/L2 cell switch command. If their decision is to use DCI, then RAN1 will start our work on the exact design of the DCI.

##### [FL proposal 4-1-v1]

* From RAN1 point of view, both DCI and MAC CE based L1/L2 cell switch command can be considered, and it is expected that RAN2 will make the final decision on which one to employ.
	+ Interested companies are encouraged to perform technical analysis from RAN1 point of view, e.g.
		- Necessary information included in the command, which is relevant for RAN1 discussion
		- Necessary number of bits for the information
		- L1 impact or concern to use DCI or MAC CE for L1/L2 cell switch command
	+ An LS can be sent to RAN2, as necessary
* The discussion on UE-initiated dynamic cell switch will be held in RAN2 first. RAN1 discussion can be started after receiving explicit indication from RAN2.
* *FL Note: FL doesn’t see a strong necessity to make any agreement/conclusion for this proposal at this meeting while some email discussion is expected in this meeting. The result of the email discussion will be used as a reference for RAN1#111.*
* *FL note: this issue is a high priority issue, but should be led by RAN2*

##### [Discussion on proposal 4-1-v1]

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## Preparation for handover before reception of cell switch command

##### [Summary of contributions]

* Based on the discussion on time chart in RAN2, companies have proposed their own view which part of UE procedures, i.e. DL Synchronization, UL synchronization and TRS tracking and CSI acquisition, can be performed before cell switch command.
	+ For DL synchronization
		- the UE should acquire the DL synchronization before processing the handover command, which can be achieved by storing QCL properties (when measurement is performed) for RSs for a certain period.
		- TCI states for target cell can be activated before the command
	+ For UL synchronization
		- Should be discussed in another AI, 9.12.2
	+ For TRS tracking and CSI acquisition
		- TRS tracking (obtaining QCL-TypeA RS) and CSI measurement for potential target cell(s) should be performed before handover, or can be triggered by cell switch command.
		- If so, RAN1 needs to discuss how to configure the necessary parameters for the target cells and how to active it.
* There is a proposal that discussion on potential L1 signaling design and enhancements on L1 measurement/reporting related to dynamic serving cell switch should be deprioritized till further RAN2 inputs are provided.

##### [FL observation]

Despite of the companies’ proposals in this meeting, FL thinks the proposals from the companies are based on the “ongoing RAN2 discussion”, and RAN2 has not concluded yet which procedure should/can be done before the command. While RAN1 spec impact is foreseen, RAN1 should wait for the formal input from RAN2 regarding their final decision on what is the expected time chart achieved by Rel-18 L1/L2 mobility.

##### [FL proposal 5-1-v1]

* RAN1 to further study the potential RAN1 enhancements and spec impact to perform the following procedures prior to the reception of L1/L2 cell switch command aiming at the reduction of handover delay / interruption
	+ DL synchronization for potential target cell(s)
	+ TRS tracking for potential target cell(s)
	+ CSI acquisition for potential target cell(s)
	+ Note: Uplink synchronization aspect will not be discussed under this A.I.
* Detailed discussion will be commenced after receiving RAN2 LS.
* *FL note: FL doesn’t see a strong necessity to make any agreement/conclusion for this proposal at this meeting while some email discussion is expected in this meeting. The result of the email discussion will be used as a reference for RAN1#111.*
* *FL note: this issue is a high priority issue*

##### [Discussion on proposal 5-1-v1]

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## Other topics

### BFR for Rel-18 L1/L2 mobility

##### [Summary of contributions]

* Two companies propose enhancements for BFR in conjunction with Rel-18 L1/L2 mobility, which is to choose non-serving cell as beam failure recovery.
	+ Support the UE updates the beam for channels including both dedicated and non-dedicated channels based on the newly reported beam requiring serving cell change after 28+X symbols after the UE receives the BFR response
		- X is the delay for serving cell change
	+ Support beam failure recovery on resources of non-serving cell.

##### [FL observation]

BFR is not clearly described in the WID, and this enhancement is proposed by two companies in this meeting. Thus, FL would encourage proponents and interested companies to have further assessments until RAN#111, and come back based on companies’ contribution, if necessary, even though WID revision may be required for RAN1 work.

##### [FL proposal 6-1-v1]

* Companies are encouraged to further study the necessity of BFR enhancements in conjunction with Rel-18 L1/L2 mobility. The discussion can be held in the future RAN1 meetings based on companies’ contribution.
* *FL note: this issue is a low priority issue at least in this meeting*

##### [Discussion on proposal 6-1-v1]

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### Interaction between inter-cell mTRP and L1/L2 mobility

##### [Summary of contributions]

One company points out the interaction between Rel-17 ICBM and Rel-18 L1/L2 handover, and the potential scenarios are shown in their contribution (see section 2.4 of R1-2208500). More concretely, Rel-17 ICBM can be operated before L1/L2 mobility, and inter-cell mTRP can also be activated right after the mobility. R1-2208500 proposes to clarify the possible scenario(s).

##### [FL observation]

Even though the proponent company propose to study the scenario in R1-2208500 first, FL wonders if the scenarios listed in this contribution is the major use cases to be addressed in this WI (in other word, this discussion is essential to realize Rel-18 L1/L2 mobility). Interested companies are encouraged to review section 2.4 of R1-2208500, and input their contributions in the next meetings, as necessary.

##### [FL proposal 6-2-v1]

* Interested companies to review section 2.4 of R1-2208500 and bring a contribution in the future RAN1 meetings.
* *FL note: this issue is a low priority issue at least in this meeting*

##### [Discussion on proposal 6-2-v1]

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### Measurement requirements

##### [Summary of contributions]

An issue is raised by R1-2208679 regarding the measurement requirement, which mentions that the overall process can be accelerated by applying the same requirements for intra-frequency and inter-frequency measurement:

* The intra-frequency measurements used for L1/L2 mobility have the same requirements as the intra-frequency measurements
* The inter-frequency measurements used for L1/L2 mobility have the same requirements as the inter-frequency measurements.

Otherwise, the measurements could not be performed at the same time. Then, it is proposed to send an LS to RAN4 describing the accuracy requirements for the measurements used for L1/L2 mobility.

#####  [FL observation]

Given the fact that inter-frequency mobility scenario has not been agreed in RAN2, it would be premature to discuss this issue. In addition, it is not clear why this discussion is triggered in RAN1. RAN2 (as a leading WG) or RAN4 should discuss this issue directly to avoid the overhead.

##### [FL proposal 6-3-v1]

* Interested companies are encouraged to bring intra-frequency and inter-frequency measurement requirement issue to RAN2 and/or RAN4.
* *FL note: this is a low priority issue at least for RAN1 from FL perspective.*

##### [Discussion on proposal 6-3-v1]

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# Annex

# WID in RP-222332

The detailed objective of this work item is captured below:

1. To specify mechanism and procedures of L1/L2 based inter-cell mobility for mobility latency reduction:
* Configuration and maintenance for multiple candidate cells to allow fast application of configurations for candidate cells [RAN2, RAN3]
* Dynamic switch mechanism among candidate serving cells (including SpCell and SCell) for the potential applicable scenarios based on L1/L2 signalling [RAN2, RAN1]
* L1 enhancements for inter-cell beam management, including L1 measurement and reporting, and beam indication [RAN1, RAN2]
	+ *Note 1: Early RAN2 involvement is necessary, including the possibility of further clarifying the interaction between this bullet with the previous bullet*
* Timing Advance management [RAN1, RAN2]
* CU-DU interface signaling to support L1/L2 mobility, if needed [RAN3]

*Note 2: FR2 specific enhancements are not precluded, if any.*

*Note 3: The procedure of L1/L2 based inter-cell mobility are applicable to the following scenarios:*

* + - *Standalone, CA and NR-DC case with serving cell change within one CG*
		- *Intra-DU case and intra-CU inter-DU case (applicable for Standalone and CA: no new RAN interfaces are expected)*
		- *Both intra-frequency and inter-frequency*
		- *Both FR1 and FR2*
		- *Source and target cells may be synchronized or non-synchronized*
1. To specify mechanism and procedures of NR-DC with selective activation of the cell groups (at least for SCG) via L3 enhancements:
* To allow subsequent cell group change after changing CG without reconfiguration and re-initiation of CPC/CPA [RAN2, RAN3, RAN4]

*Note 4: A harmonized* RRC modelling approach for objectives 1 and 2 could be considered to minimize the workload in RAN2.

1. To specify data forwarding optimizations for CHO including target MCG and target SCG in NR-DC [RAN3].
2. To specify CHO including target MCG and candidate SCGs for CPC/CPA in NR-DC [RAN3, RAN2]
* CHO including target MCG and target SCG is used as the baseline
1. To specify RRM core requirements for the following, as necessary [RAN4]:
* L1/L2-based inter-cell mobility
* Enhanced CHO configurations addressed by this WI
1. To specify RF requirements to cover inter-frequency L1/L2-based mobility, as necessary [RAN4].
2. To study the following, with completion targeted by RAN#98 meeting [RAN4]:
* The impact of FR2 RRM mobility measurement acquisition and reporting on FR2 SCell/SCG setup/resume delay for a UE connecting from idle/inactive mode.
* The level of feasible improvement in FR2 SCell/SCG setup delay from defining new UE measurement procedures and RRM core requirements, and whether additional information from the network would help the UE to perform those measurements effectively. The following sequence of events should be assumed.
	+ - The UE initiates and performs improved measurements when it requests RRC connection setup/resume.
		- After acquiring those improved measurements, the UE subsequently reports those measurements to the network to support SCell/SCG setup.

# TU allocation

