**3GPP TSG RAN WG1 #103-e- R1-2009415**

**e-Meeting, October 26th – November 13th, 2020**

Source: moderator (vivo)

Title: Feature lead summary on Enhancements on Multi-TRP inter-cell operation

Agenda Item: 8.1.2.2

Document for: Discussion and Decision

1. Introduction

The following agreements were achieved in RAN1 #102e.

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| **Agreement**Study the following aspects of QCL /TCI-related enhancement to enable inter-cell multi-DCI based multi-TRP operation.* Details on configuration of non-serving cell RS;
* Allowed source and target RS types for RS transmitted from the non-serving cell TRP ;
* Allowed QCL types for RS transmitted from the non-serving cell TRP ;
* Measurement and reporting related to QCL /TCI enhancement except for that in 8.1.1, if any;
* Clarification on potential UE behavior for associating/multiplexing non-serving cell RS with other RS/channels;
* Other details not precluded.
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In this contribution, contributions submitted in AI 8.1.2.2 are summarized. In section 2, the points raised in the contributions are listed.

1. 1. Item 1: QCL/TCI state/spatial relation configuration

For the detials on configurationof non-serving cell RS, there are mainly two issues mentioned from contributions (including [R1-2007541], [R1-2007646], [R1-2007765], [R1-2007826], [R1-2008002], [R1-2008150], [R1-2008219], [R1-2008348], [R1-2008440], [R1-2008905], [R1-2008912], [R1-2008945]):

Issue 1: the following information needed for configuration are mentioned by companies: PCI, SSB Periodicity, SSB position in burst and frequency position, beam sweeping property, or MeasObjectId

Majority companies support configuration of at least PCI for non-serving cell, based on the input the following FL proposal is proposed:

**FL Proposal 1-1:**

* **Non-serving cell information for inter-cell MTRP operation at least includes non-serving cell PCI**
* **FFS whether the following non-serving cell information is needed: SSB Periodicity, SSB position in burst, frequency position, beam sweeping property, MeasObjectId**
* **FFS introducing a flag to represent non-serving cell information**

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| Company | comments |
| CATT | At least the periodicity and frequency posisition of SSB in non-serving cell are needed. |
| vivo | Support the FL proposal.. |
| ZTE | We are supportive of Proposal 1-1 in principle. But some wording should be refined.In order to identify the unique SSB from neighbor cell as QCL source, additional information besides PCI is needed, such as absolution frequency, SCS, etc. Meanwhile, additional information of neighbor cell SSB have been configured during mobility measurement processing. Specifically, on the other hand, those information (e.g., PCIs of multiple neighbor cells, *ARFCN-ValueNR* for frequency position, SCS for SSB, SMTC, etc.) are included in *MeasObjectNR* configured for each UE, each of which is identified by MeasObjectId. Thus, as per our view, configure PCI and MeasObjectId is sufficient to introduce neighbor cell SSB in TCI state as QCL source. It is noted that MeasObjectId contains the SSB information, and it can be used to carry SSB information. But it is not one property of SSB. So our suggestion is as followsProposal 1-1: * Non-serving cell information for inter-cell MTRP operation at least includes non-serving cell PCI
* FFS whether the following non-serving cell information is needed: SSB Periodicity, SSB position in burst, frequency position, beam sweeping property, subcarrier spacing, SMTC
* FFS how to configure the non-serving cell information, e.g. MeasObjectId + PCI
* FFS introducing a flag to represent non-serving cell information
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Issue 2: various configuration methods are proposed by companies, including non-serving cell information is indicated in the TCI state, group TCI state and associate non-serving cell information with each group, non-serving cell information is indicated in the CSI-ReportConfig, non-serving cell information is indicated in the CSI-ResourceConfig, introduce a flag to represent non-serving cell information SSB. With these configuration method in mind, the following proposal is proposed:

**FL Proposal 1-2:**

**Support configuration of non-serving cell information with one or multiple of the following alternatives**

* **Alt 1: Non-serving cell information is indicated in the TCI state**
* **Alt 2: Group TCI state and associate non-serving cell information with each group**
* **Alt 3: Non-serving cell information is indicated in the CSI-ResourceConfig**
* **Alt 4: Non-serving cell information is indicated in the CSI-ReportConfig.**

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| Company | comments |
| CATT  | Alt 1 is preferred. |
| vivo | Support FL proposal.Support both Alt1 and Alt3. |
| ZTE | We are supportive of this proposal. Alt 2 is our preference.Due to the geographical locations of serving cell TRP and neighbor cell TRP are different, the propagation and channel characteristic associated with data streams of the two TRPs are generally different. Correspondingly, configurations of TCI states of serving cell and neighbor cell should be TRP specific. Furthermore, in Rel-16 NR eMIMO, the parameter *CORESETPoolIndex* has been introduced to support multi-DCI based Multi-TRP configurations, such as separate HARQ-ACK, power control, etc. Therefore, to better support Multi-TRP inter-cell operation in NR Rel-17, we think the parameter *CORESETPoolIndex* should be associated with the group TCI state. For instance, *CORESETPoolIndex* = 0 corresponds to the serving cell and *CORESETPoolIndex* = 1 corresponds to the neighbor cell.Besides, from our perspective, Alt. 1 will cause unnecessary signaling overhead. The benefit of Alt.3 and Alt.4 is unclear for us. |

* 1. Item 2: Allowed RS types and QCL types

Regarding the allowed RS types and QCL types, there are the following issues mentioned by companies ([R1-2007541], [R1-2007588], [R1-2007588], [R1-2007646], [R1-2007765], [R1-2007826], [R1-2008002], [R1-2008150], [R1-2008440], [R1-2008575], [R1-2008912], [R1-2008945]):

Issue 2-1: Whether SSB and CSI-RS for mobility from non-serving cell configured as non-serving cell RS. Majority companies supports to configure SSB from non-serving cell configured as non-serving RS. Several companies also support CSI-RS for mobility configured as non-serving RS. For other RS types, e.g. TRS, whether they can directly configured and the corresponding spec impact also needs further study.

**FL Proposal 2-1: Support to configure SSB and CSI-RS for mobility from non-serving cell configured as non-serving cell RS.**

* **FFS : other RS type and their spec impact.**

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| Company | comments |
| CATT | Support to configure SSB from non-serving cell as non-serving cell RS |
| vivo | Support FL proposal. |
| ZTE | We are supportive of Proposal 2-1. Moreover, we are fine to use the neighbor cell TRS as the QCL source in TCI state. |

Issue 2-2: Several companies propose to allow TRS, CSI-RS, DL DMRS to be associated with non-serving cell RS. Based on these inputs, the following FL proposal is made:

**FL Proposal 2-2: Support to associate TRS, CSI-RS(for beam management and for CSI acquisition), DMRS with non-serving cell RS.**

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| Company | comments |
| CATT | Support this proposal. |
| vivo | Support FL proposal. It could be further clarified that the DMRS includes the DMRS of PDSCH and PDCCH. For the target signal of DMRS of PDCCH, further clarification in item 7 is needed. |
| ZTE | Support |

* 1. Item 3 : measurement and reporting

Measurement and reporting related to non-serving cell RS is also mentioned by several companies, including coordination with the mobility discussion. Based on the input from [R1-2007541] [R1-2007646] [R1-2008219] [R1-2008440] [R1-2008905], the following proposals are made.

**FL Proposal 3-1: Further study the following aspects related to measurement and reporting related to non-serving cell RS, if not cover by AI 8.1.1:**

* **Whether and how L1 measurement of non-serving cell RS are configured**
* **Whether and how L1 reporting of non-serving cell RS measurement needs to be enhanced.**

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| Company | comments |
| CATT | It’s not necessary to enhace measurement and reporting to non-serving cell RS.  |
| vivo | Support to further study L1 measurement of non-serving cell RS. |
| ZTE | To avoid the overlapping/parallel discussion of L1-centric measurement/reporting in AI 8.1.1, we suggest that the further discussion on L1 measurement/reporting of non-serving cell RS may happen after AI 8.1.1 discussions or based on additional RAN guidance. |

* 1. Item 4 : Enhancement for UL

Enhancement for UL towards target cell are also supported by several companies. Based on contributions submitted ([R1-2007541], [R1-2007646], [R1-2007826], [R1-2008219]), the following FL proposal is proposed.

**FL proposal 4-1: Further study spatial relation and power control related enhancement for SRS, PUCCH, PUSCH transmission towards a non-serving cell TRP.**

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| Company | comments |
| CATT | UL enhancement is out of the scope.  |
| vivo | Support to enhance UL related aspects either in this item or in MB item. |
| ZTE | Support |

* 1. Item 5: clarification on synchronization, UL/DL timing

The timing issues are intensely discussed in RAN1 102e and also in plenary, based on the contribution ([R1-2007541], [R1-2007646], [R1-2008575], [R1-2007765]), the FL proposal is made as following to both allow the network to deploy inter-cell MTRP operation with relaxed timing requirement and relax UE implementation without the necessity to simultaneously receive non-sync signals from M-TRP.

**FL proposal 5-1: For inter MTRP operation, UE can be configured with signals with different QCL source timing, with the restriction that UE does not expect to receive signals with timing offset beyond CP simultaneously.**

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| Company | comments |
| CATT | Support this proposal. |
| vivo | Support FL proposal. |
| ZTE | The timing issues related to Multi-TRP inter-cell operation has been discussed in previous RAN plenary meeting and then has been precluded during the drafting process of the WID. Meanwhile, considering the limited time budget and the large scope for the current Rel-17 NR FeMIMO, we prefer to deprioritize this issue compared with QCL/TCI-related enhancement. |

* 1. Item 6: Rate matching

Rate matching related issues are proposed by several companies ([R1-2007646], [R1-2008219], [R1-2008440]). The following FL proposal is made based on these input.

**FL proposal 6-1: Further study rate matching behavior related to non-serving cell RS.**

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| Company | comments |
| vivo | Support FL proposal |
| ZTE | Support |

* 1. Item 7: CORESETs configuration

CORESETs configuration for inter-cell MTRP operation is also discussed by contributions. Based on the input([R1-2007646], [R1-2008905]), the following FL proposal is made.

**FL proposal 7-1: Further study how to configure CORESETs associated with non-serving cell for inter-cell MTRP operation, including possible configuration restrictions on CORESETs with common search space.**

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| Company | comments |
| vivo | Support FL proposal. |
| ZTE | Support |

* 1. Item 8: Others

The following proposal is intended to down-select deployment scenarios for inter-cell MTRP operation([R1-2007628]). Please share your comments for this proposal

Proposal 1 from [R1-2007628]: For inter-cell M-TRP operation down-select one of the following alternatives

Alt1 - Inter-cell M-TRP is supported only for FR1 operation with a subcarrier spacing of 15 KHz

Alt2 - Inter-cell M-TRP is supported only based on UE capability

* + Similar to Rel-16 UE DAPS, the capability signalling may comprise of the following parameters:
		- interCellAsync-r17 indicates whether the UE supports asynchronous DAPS handover.
		- interCellDiffSCS-r17 indicates supported subcarrier spacings

Alt3 - Inter-cell M-TRP is supported only based on cell synchronization accuracy in a given M-TRP deployment

Alt4 – All of the above

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| Company | comments |
| CATT | Alt3 is preferred. |
| ZTE | Same as item 5, we prefer to deprioritize this issue compared with QCL/TCI-related enhancement. |

1. Reference

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| R1-2007541 | Inter-cell multi-TRP operation | FUTUREWEI |
| Proposal 1: For inter-cell multi-TRP enhancement:* Propagation delay difference is equal to or larger than that of Rel-16 considering URLLC use cases and large cells;
* Further clarify the scenario and key assumptions on synchronization, backhaul, and UL support:
	+ Clarify FR1 synchronization offset and backhaul between two TRPs, and whether the resulting signals can be beyond the CP length for the UE or not
	+ Clarify FR2 synchronization offset and backhaul between two TRPs, and whether the resulting signals can be beyond the CP length for the UE or not

Proposal 2: For inter-cell multi-TRP enhancement, QCL/TCI state can include a non-serving cell PCI/SSB/RS, and reuse Rel-16 scheme for a non-serving cell’s SSB/RS configuration as much as possible but remove parameters common between the M-TRPs (e.g., BWP BW, SCS, etc.).Proposal 3: For inter-cell multi-TRP, configure an optional SSB search time window when configuring a neighbor cell’s SSB/PCI.Proposal 4: For inter-cell multi-TRP, allow QCL types of all existing QCL types and DL-UL spatial relation info and SRI and PL RS relation.Proposal 5: For inter-cell multi-TRP, allow source RS to be SSB, TRS, and CSI-RS, and target RS to be TRS, CSI-RS, DL DMRS, SRS, and UL DMRS.Proposal 6: For inter-cell multi-TRP, UE shall perform measurement and reporting for non-serving cell based on network configuration.Proposal 7: For inter-cell multi-TRP, study the minimum standard support for UE to receive DL signals with different arrival timings and to transmit UL signals with different timings. |
| R1-2007588 | Enhancements on inter-cell multi-TRP operations in Rel-17 | Huawei, HiSilicon |
| The following proposals are provided,Proposal 1: Support using NZP-CSI-RS from a non-serving cell or CSI-RS for mobility associated with a non-serving cell as QCL source for multi-DCI multi-TRP transmission.Proposal 2: Extend QCL association type applicability such as QCL-TypeA/B/C to CSI-RS for mobility for inter-cell M-TRP operation. |
| R1-2007628 | Synchronization Analysis for M-TRP Inter-cell Operation | InterDigital, Inc.  |
| Proposal 1: For inter-cell M-TRP operation down-select one of the following alternativesAlt1 - Inter-cell M-TRP is supported only for FR1 operation with a subcarrier spacing of 15 KHzAlt2 - Inter-cell M-TRP is supported only based on UE capability* Similar to Rel-16 UE DAPS, the capability signalling may comprise of the following parameters:
	+ interCellAsync-r17 indicates whether the UE supports asynchronous DAPS handover.
	+ interCellDiffSCS-r17 indicates supported subcarrier spacings

Alt3 - Inter-cell M-TRP is supported only based on cell synchronization accuracy in a given M-TRP deploymentAlt4 – All of the above |
| R1-2007646 | Further discussion on inter-cell MTRP operation | vivo |
| Proposal 1: Inter-cell multi-TRP operation in Rel-17 should consider both ideal backhaul and non-ideal backhaul scenarios.Proposal 2: Inter-cell multi-TRP operation in Rel-17 should consider both QCL enhancement for DL and spatial relation enhancement for UL.Proposal 3: Inter-cell m-TRP enhancement should consider both of the following two aspects:* TCI state configuration/activation enhancement with additional information of the target cells (at least including PCI information)
* Enhanced configuration/activation of L1 measured SSBs/CSI-RS with additional information of the target cells.

Proposal 4: Clarify UE behaviour for receiving signals associated with different QCL source timing, with the restriction that UE does not expect to receive signals with timing offset beyond CP simultaneously.Proposal 5: Configuration of L1 measurement of non-serving cell RS should enable inter-cell L1 measurement of a target cell for both the case with and without corresponding inter-cell L3 measurement of the target cell.Proposal 6: Consider configuring inter-cell L1 measurement for a target cell with similar structure as MeasObjectNR for L3 measurement.Proposal 7: Inter-cell L1 measurement is enabled through the following two ways* For cases when the inter-cell L1 measurement is associated with L3 measurement, the measurement is enabled through normal CSI measurement configuration by associating (the QCL source of) an L1 measured RS with an RS configured for L3 measurement.
* For cases when the inter-cell L1 measurement is not associated with any L3 measurement, the measurement is enabled through signalling with similar structure as MeasObjectNR for L3 measurement.

Proposal 8: L1 measurement limited within SMTC and without limitation should both be supported.Proposal 9: Support to configure L1 reporting of non-serving cell RS measurement results based on Rel-15/16 L1 reporting setting configuration with enhancement on association of the RS with a target measurement object.Proposal 10: Timing offset between different signals should be reported from UE to determine whether Rx timing the signals from multi-TRP are within CP or not.Proposal 11: Clarify UE behaviour when CORESETs with type 0/1/2 SS is configured/activated with TCI states associated with SSB of another PCI.Proposal 12: CSI-RS for CSI, beam management and tracking should all be allowed to be associated with non-serving cell RS for L1 inter-cell measurement.Proposal 13: Rel-15/16 configuration restriction on the source and target RS/channel of QCL chains is also applied for Rel-17 inter-cell operation.Proposal 14: Spatial relation and power control related configurations should be enhanced for SRS, PUCCH, PUSCH transmission towards target cell. |
| R1-2007765 | Discussion on Multi-TRP inter-cell operation | ZTE |
| Proposal 1: Support SSB and CSI-RS for mobility from the neighbor cell to be used as the QCL source.* Configure MeasObjectId and PCI to identify the SSB and CSI-RS from a neighbor cell.

Proposal 2: All TCI states should be split into two groups corresponding to the serving cell and the neighbor cell respectively.* Each group is associated with a CORESETPoolIndex value.

Proposal 3: Support neighbor cell TRS as the QCL source in TCI, where the sequence generation of the neighbor cell TRS is based on slot index of neighbor cell.Proposal 4: In Rel-17, deprioritize the discussion of the issue about UL and DL synchronization assumptions. |
| R1-2007826 | Discussion on multi-TRP/panel inter-cell operation | CATT |
| Proposal 1: SSB of non-serving cell can be used as source QCL for RSs transmitted from that cell in inter-cell M-TRP operation, and CSI-RS can be used as source QCL as well when SSB is absent.Proposal 2: Periodicity and frequency position of non-serving cell SSB can be configured.Proposal 3: Include the PCI of non-serving cell in RRC configured TCI states referring to the non-serving cell source QCL RS.Proposal 4: For non-serving cell, the source QCL RS can be configured as PUCCH resource spatial relation and be configured as PUCCH pathloss RS. |
| R1-2008002 | Enhancements on Multi-TRP inter-cell operation | CMCC |
| Proposal 1: Non-serving cell SSBs with an independently configured PCI should be configured to UE.Proposal 2: Both SSB and CSI-RS could be source RS transmitted from the non-serving cell, and both CSI-RS and DMRS could be target RSs transmitted from the non-serving cell.Proposal 3: An indication, such as PCI, should be configured in TCI state to enable the SSB from non-serving cell can be referenced as a QCL source.  |
| R1-2008150 | Enhancements on Multi-TRP inter-cell operation | Samsung |
| Proposal 1: Support the use of SSBs from the serving-cell TRP as the QCL source/reference for the downlink transmissions from the non-serving-cell TRP depending on the QCL type* The information of the SSBs from the non-serving-cell TRP may need to be available at the UE, and their monitoring/measurement procedure may also need to be specified.
* For QCL-typeD, the SSBs from the non-serving-cell TRP should be the only QCL source for the DL transmission, e.g., a TRS, from the non-serving-cell TRP.
* For other QCL types than QCL-typeD, the SSBs from the serving-cell TRP could be used as the QCL source for the DL transmission, e.g., a TRS, from the non-serving-cell TRP.

Proposal 2: Apply SSB re-indexing to the SSBs from the non-serving-cell TRP. If a SSB from the non-serving-cell TRP is used as the QCL source RS, its new index, i.e., after applying the SSB re-indexing over its original index, is indicated in the TCI state. |
| R1-2008219 | Enhancement on inter-cell multi-TRP operation | OPPO |
| Proposal 1: For non-serving cell RS,* Non-serving cell RS includes neighboring cell SSB.
* Neighboring cell SSB can be source RS for TRS and CSI-RS for beam management, w.r.t QCL type C and/or QCL type D. FFS whether it can be the source RS/pathloss RS for UL signal/channel.
* Introduce a flag to indicate neighboring cell SSB in QCL information.
* SSB configuration information of one neighboring cell is sufficient for inter-cell multi-DCI based multi-TRP operation, which can be configured independently from QCL information.
	+ Consider to reuse the signaling structure of SSB configuration in spatial relation information of positioning SRS or to link the SSB configuration information to mobility measurement.

Proposal 2: L1-beam measurement/reporting based on neighboring cell SSB should have low priority.Proposal 3: If SSB of neighboring cell is included in TCI state or CSI resource, the other DL signal should not be impacted by the SSB, e.g. the other DL signal are not rate-matched and can be transmitted in the same symbol as the SSB. |
| R1-2008348 | Considerations on inter-cell operation | Sony |
| Proposal 1 Non-serving cell information such as Cell ID or Physical Cell ID for RS shall be added in the CSI-ReportConfig.Proposal 2 QCL information among CSI-ResourceConfig in terms of beam sweeping property shall be included in the CSI-ReportConfig. |
| R1-2008440 | Views on Rel-17 Inter-cell multi-TRP operation | Apple |
| Proposal 1: Support to divide TCI states into N groups, where each group is associated with a physical cell ID.* Support to configure the physical cell ID, SSB transmission power, SSB periodicity, SSB position in burst and offset to point A for a TCI state group.

Proposal 2: UE shall expect the signals associated with the same CORESET pool should be associated with the same physical cell ID from QCL indication perspective.Proposal 3: The allowed QCL type for assistant cell should reuse what has been defined for serving cell QCL indication.Proposal 4: Further enhancement on measurement and reporting related to QCL/TCI enhancement should wait for the outcome of 8.1.1.Proposal 5: For assistant cell signals, the resources for assistant SSBs should be considered as “not available”.* For serving cell signals, whether resources for assistant SSBs should be considered as “not available” or not should be reported by UE capability.
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| R1-2008575 | Enhancements on Multi-TRP inter-cell operation | LG Electronics |
| Proposal #1: Reuse neighbor cell’s SSB or mobility CSI-RS in measurement object for QCL type C/D source of TRS/CSI-RS to support inter-cell multi-TRP operations. Proposal #2: For inter-cell MTRP transmission, consider the case that the timing difference/offset between two TRPs at the UE side is larger than 1 CP due to imperfect network synchronization and the large difference of propagation delay in FR 2. |
| R1-2008905 | Enhancements to enable inter-cell multi-TRP operations | Nokia, Nokia Shanghai Bell |
| Proposal 1: To configure SSB as non-serving cell RS, indicate the associated cell (PCI) for the SSB in the *referenceSignal* parameter. Proposal 2: Allow configuration of TCI State of non-serving cell RS to the serving cell TCI State list. Proposal 3: To configure NZP-CSI-RS resource as non-serving cell RS, configure the RS with a QCL source RS that is associated with a non-serving cell.Proposal 4: For L1 SSB based beam measurements and reporting, enhance SSB-index parameter in the *CSI-SSB-ResourceSet IE* to associate set of SSBs with a cell specific identifier (PCI). Proposal 5: For non-serving cell CSI-RS measurements, configure the NZP-CSI-RS with a QCL source RS that is associated with a non-serving cell identifier.Proposal 6: For inter-cell multi-DCI based multi-TRP support, extend the TCI framework using the Rel-16 multi-DCI based multi-TRP framework. Proposal 7: The non-serving cell CORESET(s) can be configured on the serving cell PDCCH-config. |
| R1-2008912 | Enhancements on Multi-TRP inter-cell operation | Lenovo, Motorola Mobility |
| Proposal 1: SSB from a non-serving cell can be set as the source QCL-TypeC and QCL-TypeD RS for TRS, CSI-RS for beam management and CSI-RS for CSI acquisition.Proposal 2: PCI can be introduced in QCL-Info to enable the use of SSB from non-serving cells as QCL-TypeC and QCL-TypeD source. Proposal 3: Enhancements on intra-cell multi-TRP operation should also be considered. |
| R1-2008945 | Discussion on multi-TRP inter-cell operation | NEC |
| Proposal: SSB from non-serving cell should be supported for source RS, and PCI, time/frequency resource of the SSB should be configured to UE. |