**3GPP TSG RAN WG1 #106bis-e R1-210xxxx**

**e-Meeting, 11 – 19 October, 2021**

**Agenda item:** 8.1.1

**Source:** Moderator (Nokia)

**Title:** Moderator summary for LS reply to RAN2 on inter-cell beam management and multi-TRP in Rel-17

**Document for:** Discussion and Decision

## Introduction

This summary includes the following:

* Proposed LS replies to the LSs from RAN2 R2-2108925
* Summary of companies’ inputs on the proposed replies

## List of companies’ contributions

The following input Tdocs were submitted:

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| [R1-2110076](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2110076.zip) | Draft reply LS to RAN2 on inter-cell beam management and multi-TRP in Rel-17 | LG Electronics |
| [R1-2110363](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2110363.zip) | Views on RAN2 LS for inter-cell BM in R17 | Huawei, HiSilicon |
| [R1-2109049](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2109049.zip) | Discussion on LS on inter-cell beam management and multi-TRP in Rel-17 | OPPO |
| [R1-2109114](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2109114.zip) | Draft reply LS on inter-cell beam management and multi-TRP in Rel-17 | vivo |
| [R1-2109257](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2109257.zip) | Draft reply LS on inter-cell beam management and multi-TRP in Rel-17 | ZTE |
| [R1-2109376](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2109376.zip) | Draft Reply LS to RAN2 LS on on inter-cell beam management and multi-TRP in Rel-17 | Xiaomi |
| [R1-2109464](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2109464.zip) | Draft Reply LS on inter-cell beam management and multi-TRP in Rel-17 | Samsung |
| [R1-2109869](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2109869.zip) | Draft reply LS to RAN 2 LS on inter-cell beam management and multi-TRP in Rel-17 | Nokia, Nokia Shanghai Bell |
| [R1-2109900](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2109900.zip) | [DRAFT] Reply LS on inter-cell beam management and multi-TRP in Rel-17 | Lenovo, Motorola Mobility |
| [R1-2109947](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2109947.zip) | Discussion on LS reply on inter-cell beam management and multi-TRP in Rel-17 | Intel Corporation |
| [R1-2110008](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2110008.zip) | Draft Reply LS on Inter-cell Beam Management and Multi-TRP | Apple |
| [R1-2110159](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2110159.zip) | Draft reply LS on inter-cell beam management and multi-TRP in Rel-17 | Qualcomm Incorporated |
| [R1-2110346](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2110346.zip) | Discussion of RAN2 LS on inter-cell BM and mTRP | Ericsson |

## Summary of companies’ inputs and proposed LS answers

The RAN2 LS is addressing 5 main topics: 1) Applicability of inter-cell beam management to mTRP, 2) Basic Tx/Rx operation with inter-cell beam management, 3) MAC aspects, 4) HARQ operation, 5) Physical layer configuration.

In order to simplify the discussion, we are dedicating below separate sections for company views and LS proposed reply.

### **Reply on the applicability of inter-cell beam management to mTRP**

Based on the above inputs, the following reply is proposed:

Table 1 Proposed reply to RAN2

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| **Question 1: RAN2 notes that WI objective 1 states " The same beam measurement/reporting mechanism will be reused for inter-cell mTRP "). RAN2 would like to understand if the entire inter-cell BM is also applicable to inter-cell mTRP? If not, which part is not applicable to mTRP and how does that work?**  **Answer 1**: Rel17 Inter-cell BM and inter-cell mTRP have common points but they are not entirely the same. The common and different points are as follows: they both use the same beam measurement/reporting mechanisms but they have different TCI signaling framework (beam indication) as inter-cell BM is based on Rel17 unified TCI while inter-cell mTRP is based on Rel15/16 TCI framework. For inter-cell BM, UE assumes that the UE-dedicated channels/RSs can be switched to a TRP with different PCI according to DCI/MAC-CE based unified TCI update; for inter-cell mTRP, UE assumes that individual TRP-specific RS/channel operations are performed based on the mDCI-mTRP scheme. |

Table 2 Tdoc based companies’ inputs on the applicability of inter-cell beam management to mTRP

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| LGE: No, the entire inter-cell BM is not applicable to inter-cell mTRP. The statement in WID is about beam measurement/reporting which is not directly tied to beam indication. With respect to beam indication, inter-cell BM will be supported based on a new TCI signaling framework to be introduced in Rel-17 while inter-cell mTRP feature will be based on Rel-15/16 TCI signaling. Therefore, beam indication method being developed for inter-cell BM will not be applicable to inter-cell mTRP.  HW: According the WID objective, inter-cell beam management involves “L1-only measurement/reporting (i.e. no L3 impact) and beam indication associated with cell(s) with any Physical Cell ID(s)”, and “same beam measurement/reporting mechanism will be reused for inter-cell mTRP”. In addition, beam indication for inter-cell beam management is “based on Rel-17 unified TCI framework”, while “QCL/TCI-related enhancements to enable inter-cell multi-TRP operations” are to be designed “based on Rel-15/16 TCI framework”. So, beam indication of inter-cell BM is not applicable to inter-cell mTRP and separate beam indication schemes are expected to be designed.  OPPO: Only beam measurement and report mechanism is the same between inter-cell beam management and inter-cell mTRP i.e. the rest is different e.g. The inter-cell BM is based on Rel-17 unified TCI framework but the inter-cell mTRP is based on Rel-16 beam indication mechanism. They are based on different beam indication mechanisms.  VIVO: the fundamental difference between inter-cell BM and inter-cell mTRP is the TCI framework, the unified TCI framework is only applicable for inter-cell BM whereas the legacy TCI framework (i.e. Rel-15/16) is applied for inter-cell mTRP. It is expected that new TCI state signalling would be defined for unified TCI framework. The mechanism of associating TCI states and PCI-related information (e.g., SSB burst information, SSB power information) can be the similar, but the beam indication signalling would be different for the two cases.  ZTE: For beam measurement/reporting, the entire inter-cell BM is also applicable to inter-cell mTRP. But for beam indication: for inter-cell BM, UE assumes that all of UE-dedicated channels/RSs can be switched to a TRP with different PCI according to DCI/MAC-CE based unified TCI update; for inter-cell mTRP, UE assumes that individual TRP-specific RS/channel operations are performed based on the mDCI-mTRP scheme.  Xiaomi: It means only the beam measurement/reporting mechanism, not the entire inter-cell BM, will be applicable to inter-cell mTRP. The beam indication of inter-cell beam management is based on Rel-17 unified TCI framework and that of inter-cell mTRP is based on Rel15/16 TCI framework.  Samsung: Inter-cell beam management is based on the Unified TCI framework. While inter-cell mTRP is based on the legacy Rel-15/Rel-16 TCI framework. Therefore, only beam measurement/reporting mechanisms are common between inter-cell beam management and inter-cell mTRP. The beam indication mechanisms are different between inter-cell beam management and inter-cell mTRP.  Nokia: The inter-cell mTRP and inter-cell beam management, have same L1 measurement and reporting mechanism but have difference in terms of beam indication (Unified TCI / legacy TCI framework), UE capabilities, RRC configuration ( CORESETPoolIndex/mTRP framework).  Lenovo: Yes, the entire inter-cell BM is also applicable to inter-cell mTRP.  Apple: Rel-17 inter-cell BM is based on unified TCI framework, while Rel-17 inter-cell mTRP is based on Rel-16 TCI framework. In addition, Rel-17 inter-cell BM does not require UE to simultaneously receive signals from multiple cells, while Rel-17 inter-cell mTRP allows UE to receive signals from two cells simultaneously.  QC: As in revised WID, the beam indication for inter-cell BM is based on R17 unified TCI framework, while the beam indication for inter-cell mTRP is based on R15/16 framework, and as such that is the difference between inter-cell mTRP and inter-cell beam management. However, the same beam measurement/reporting mechanism for inter-cell BM will be reused for inter-cell mTRP.  Intel: We would like to confirm that same beam measurement and reporting mechanism will be used to support both inter-cell mTRP and inter-cell BM without differentiation. At the same time, since inter-cell mTRP operation relies on the existing TCI / spatial relation framework supported in Rel-16, while inter-cell BM on new Rel-17 unified TCI configuration, the entire inter-cell BM would not be applicable to inter-cell mTRP. |

Table 3 Companies’ inputs on the applicability of inter-cell beam management to mTRP

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| **Company** | **Input** |
| Mod V0 | **The proposals for this question are pretty stable, almost unanimous views on what the answer should look like. Please share your inputs on the above** |
| Samsung | We are fine with the reply. Just one small update  **Answer 1**: Rel17 Inter-cell BM and inter-cell mTRP have common points but they are not entirely the same. The common and different points are as follows: they both use the same beam measurement/reporting mechanisms but they have different TCI signaling framework (beam indication) as inter-cell BM is based on Rel17 unified TCI while inter-cell mTRP is based on Rel15/16 TCI framework. For inter-cell BM, UE assumes that the UE-dedicated channels/RSs can be switched to a TRP with different PCI according to DCI/MAC-CE based unified TCI update; for inter-cell mTRP, UE assumes that individual TRP-specific RS/channel operations are performed based on the mDCI-mTRP ~~scheme~~ based multi-PDSCH reception. |
| vivo | Fine with revision from Samsung |

### **Reply on basic Tx/Rx operation with inter-cell beam management**

Based on the above inputs, the following reply is proposed:

Table 4 Proposed reply to RAN2

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| **Question 2:** The WI states that "*For inter-cell beam management, a UE can transmit to or receive from only a single cell (i.e. serving cell does not change when beam selection is done)*". Then, when the UE is configured to use both *serving cell TRP* and *TRP with different PCI*, RAN2 would like to understand the corresponding behaviour for:  a) **UL and DL:** Are UL and DL always processed at the same TRP or can the UE use e.g. *serving cell TRP* for UL transmissions and *TRP with different PCI* for DL reception or vice-versa?  **Answer 2.a**: For inter-cell BM, there are two beam indication modes. One mode is called joint TCI, where DL and UL beams are always same. The other mode is called separate TCI, where DL and UL beams are independently indicated. For the separate TCI mode, RAN1 has not decided whether to introduce such restriction that DL and UL beams should not be set to different TRPs with different PCIs. |

Table 5 Tdoc based companies’ inputs

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| LGE: For inter-cell mTRP, it is possible because TRPs can independently schedule PDSCH. For example, UE may receive PDCCH/PDSCH from serving cell TRP while transmitting PUCCH/PUSCH to send HARQ-ACK for a previously scheduled PDSCH to a TRP with different PCI. For inter-cell BM, there are two modes. One mode is called joint TCI, where DL and UL beams are always same. The other mode is called separate TCI, where DL and UL beams are independently indicated. For the separate TCI mode, RAN1 has not been discussed/decided whether to introduce such restriction that DL and UL beams should not be set to different TRPs with different PCIs.  HW: The UE can use serving cell TRP for UL transmissions and TRP with different PCI for DL reception.  OPPO: When separate DL TCI state and UL TCI state are indicated, it is preferred that the DL TCI state and UL TCI state are associated with the same PCI/TRP.  VIVO: it is not precluded in RAN1 that UL and DL are processed at different TRPs (currently under discussion in multi beam agenda item)  Intel: There is no restriction on association of DL and UL beams to the TRPs for inter-cell beam management. In other words, it should be possible for the NW to configure separate DL and UL TCI states targeting DL and UL transmission from / to different TRPs using Rel-17 common TCI framework. At the same time, we note that inter-cell measurement in Rel-17 would only support L1-RSRP reporting (optimizing TRP selection in DL). In this case, due to lack of other information, e.g., representing link quality in the uplink, it is expected that the most common case would be DL and UL processing at the same TRP.  ZTE: Regarding DL and UL, by using Rel-17 separate DL and UL TCI state indication, the UE can use serving cell TRP for UL transmissions and TRP with different PCI for DL reception or vice-versa.  Xiaomi: This question has not been decided yet and will be discussed in follow-up meeting.  In RAN1 #106-e meeting Chairman notes, there is a FFS whether the indicated DL TCI and UL TCI are associated with SSBs of a same physical cell ID for separate DL/UL TCI, that is whether UL and DL are always processed at the same TRP.  If UL and DL are allowed to be processed at different TRP, serving cell or “neighbor cell” cannot get the HARQ-ACK feedback for the DL transmission timely if these two cells have non-ideal backhaul. While in case of ideal backhaul, processing the UL and DL transmission at different TRPs seems OK. Therefore, from our understanding, processing UL and DL transmission at the same or different TRP can be supported.  Samsung: This is still an open point in RAN1, contingent on the resolution of the FFS in the following agreement. Note that nothing else is agreed, such restriction doesn’t apply.  **Agreement**  On Rel.17 beam indication enhancements for inter-cell management, the supported Rel-17 MAC-CE-based and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation) apply to:   * Both joint TCI and separate DL/UL TCI * FFS: For separate DL/UL TCI, whether the indicated DL TCI and UL TCI are associated with SSBs of a same physical cell ID   Nokia: RAN1 has agreed to support both joint and separate TCI state for inter-cell beam management, for non UE-dedicated channels and signals. For both joint and separate DL/UL TCI, the indicated TCI are associated with SSBs of a same PCI.  Lenovo: From RAN1 perspective, DL reception from both TRPs and UL transmission to only TRP can be supported based on Rel-16 multi-DCI based multi-TRP framework.  Apple: Inter-cell BM does not mandate UE to process UL and DL at the same TRP. Non-UE dedicated signal is assumed to be from serving cell. UE-dedicated signal including both UL and DL should be associated with the same TRP.  QC: The issue is under discussion in RAN1. For inter-cell BM the common channels will be received on the serving-cell, while the dedicated UL/DL channels may be Tx/Rx on the serving or non-serving cell where UL/DL Rx/Tx is TDM. For inter-cell mTRP UL/DL Tx/Rx is based on rel-16 multi-DCI mTRP (based on CORSET pool index framework), therefore simultaneous Rx from both TRPs and TDM Tx to both TRPs are possible.  Ericsson: We see no reason why the specifications should prevent this type of operation – for the intra-cell case, the DL and UL transmissions may target different TRPs. It would seem relevant to have this as a UE capability, though. |

Table 6 Proposed reply to RAN2

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| b) **System information and short message (e.g. paging):** If UE is receiving DL data from *TRP with different PCI* on dedicated channels, is the UE still able to receive short message (e.g. paging) and system information from *serving cell TRP* at the same time?  **Answer 2.b**: system information and paging for inter-cell beam management can be only received from the serving cell TRP. When receiving PDCCH/PDSCH with colliding QCL, prioritization rule specified in Rel-15/16 can be reused. |

Table 7 Tdoc based companies’ inputs

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| LGE: For both inter-cell BM and inter-cell mTRP, the answer is Yes. UE can receive system information and short message from serving cell TRP.  HW: This depends on UE capability. UE supporting two active TCI states is able to receive short message (e.g. paging) and system information from serving cell TRP, while receiving DL data from TRP with different PCI on dedicated channels. For UE supporting only one active state, RAN1 is still discussing related design and will provide details when available.  OPPO: The TCI state indicated to PDCCH/PDSCH carrying short message and system information can only be associated with serving cell PCI. When receiving PDCCH/PDSCH with colliding QCL, prioritization rule specified in Rel-15/16 can be reused.  VIVO: No. UE can receive DL data from TRP with different PCI on dedicated channels and UE still able to receive short message (e.g. paging) and system information from serving cell TRP at different times.  ZTE: Regarding System information and short message (e.g. paging), in Rel-17, inter-cell BM is dedicated to single Tx/Rx operation, and so at a given time, only one Tx beam can be available for DL reception. That means that, if UE is receiving DL data from TRP with different PCI on dedicated channels, the UE can NOT be able to receive short message (e.g. paging) and system information from serving cell TRP at the same time.  Xiaomi: Because the serving cell will not change in inter-cell beam management, we do not see any reason for UE to stop receiving short message (e.g. paging) and system information from serving cell TRP, unless the system information from serving cell TRP and TRP with different PCI can be assumed to be the same.  Intel: According to the agreement in RAN1#106e meeting, system information and paging for inter-cell beam management can be only received from the serving cell TRP. Such system information and paging transmission should be TDM-ed with unicast transmission from TRP with different PCI.  Samsung: At any one time (e.g., in the same symbol), the UE can only receive channels associated with SSBs of a same physical cell ID. Switching from channels associated with SSBs of one physical cell ID to channels associated with SSBs of another physical cell ID is subject to UE latency requirements for inter-cell beam switching.  Nokia: RAN1 has agreed that for inter-cell beam management the beam indication applies to UE dedicated channels/signal and UE is assumed receive common channels/signals from serving cell.  Lenovo: UE can receive DL data from a TRP with different PCI on dedicated channels and receive cell-common PDCCH (e.g., paging and system information) form its serving cell at the same time as M-DCI M-TRP PDSCH.  Apple: No, according to the WID, UE can only communicate with one cell.  QC: For inter-cell BM, UE is not able to receive transmissions from different TRPs at the same time. For inter-cell m-TRP case, UE is able to receive simultaneously from all TRPs.  Ericsson: This was discussed to some extent during RAN1#106-e. It cannot in general be assumed that the UE can receive SI and/or paging at the same time as DL data. However, we do not see that the UE needs to read SI over broadcast in connected mode, and we should consider ways to provide paging using dedicated signalling, as proposed in [2]. |

Table 8 Proposed reply to RAN2

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| c) **SSB reception:** is the UE able to always receive CD-SSB from *serving cell TRP* when needed and is there any impact to RRM measurements of serving or neighbour cells?  **Answer 2.c**: The UE is always able to receive CD-SSB from serving cell TRP. There is no impact on RRM measurements of serving or neighbour cells. |

Table 9 Tdoc based companies’ inputs

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| LGE: Yes, UE is always able to receive CD-SSB from serving cell TRP. For the second question, there is no impact on RRM measurements of serving or neighbour cells.  HW: UE is always able to receive CD-SSB from serving cell TRP. There is no impact to RRM measurements of serving or neighbour cells.  OPPO: There is no additional spec impact on receiving CD-SSB and RRM.  VIVO: measurement window configured by network should ensure UE able to always receive CD-SSB from serving cell TRP with no impact  ZTE: Regarding SSB reception, the UE is able to always receive CD-SSB from serving cell TRP when needed and there is no impact to RRM measurements of serving or neighbour cells.  Xiaomi: [RAN1 reply]: UE is able to always receive CD-SSB from serving cell TRP when needed for RRM measurement. And there is no impact to RRM measurements of serving or neighbour cells.  From RAN1 perspective, the inter-cell beam management, namely L1/L2-centric inter-cell mobility, is not a substitute of the RRC handover procedure. The handover will eventually happen, but before that, NW can indicate UE TCI state associated with TRP with different PCI in inter-cell beam management which is under the framework of Rel17 beam management and based on L1/L2 signaling. Therefore, UE is able to always receive CD-SSB from serving cell TRP when needed for RRM measurement and there is no impact to RRM measurements of serving or neighbour cells  Intel: Inter-cell beam management will be supported by using SS-RSRP measurements for L1-RSRP. In this case no impact on reception of SSB from the serving cell TRP and RRM measurements is expected.  Samsung: Please see answer to question Q2b for receiving CD-SSB. There is no change in UE capability to perform RRM measurements of serving or neighboring cells.  Nokia: The release-17 unified TCI state beam indication for inter-cell beam management does not differentiate between CD-SSB and SSB.  A2c: RAN1 assumes L3 RRM measurements to be conducted as in legacy for serving and neighbour cells.  Lenovo: UE conducts measurement of L1-RSRP on SSB from non-serving cells and regular CSI measurement on SSB and CSI-RS from the serving cell. The measurement results from serving cell and non-serving can be included in the same CSI report configuration and in the same CSI report. RAN1 will determine the details of the number of non-serving cell and non-serving cell SSBs in a single CSI report in this meeting.  Apple: No impact on RRM measurement.  QC: There is no expected impact.  Ericsson: In FR1, the UE can receive SSBs from serving and neighbor cells. This property will make it possible to receive the CD-SSB from the serving cell. In FR2, the UE is not required to receive PDCCH/PDSCH or transmit PUCCH/PUSCH on SSB symbols to measure. This will guarantee that the UE can always measure serving cell SSB also in FR2. From the RAN1 point of view, there is no impact to the RRM measurements. |

Table 10 Proposed reply to RAN2

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| d) **Number of TRPs:** Is the number of TRPs involved in the operation restricted to two (i.e. *serving cell TRP* and *TRP with different PCI*? Are there any restrictions on TRPs from which UE may send/receive data, or TRPs from which the UE is assumed to be able to make L1 measurements?  **Answer 2.d**: RAN1 is still discussing the maximum number of RRC configured PCIs different from the serving cell for measurement and reporting and has made the following agreement  **Agreement**  On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, select NMAX(the maximum number of RRC configured PCIs different from the serving cell for measurement/reporting) from the following alternatives (to be decided in RAN1#106bis-e):   * Alt1: NMAXis up to UE capability with candidate values of 1 and X.   + Note: X as agreed in AI 8.1.2.2   + When NMAXis configured to be X, the UE measures up to X PCIs different from the serving cell PCI   + Additional restriction may be added by RAN4 * Alt2. NMAX=1   The related agreement made in AI 8.1.2.2 (inter-cell mTRP) during RAN1 #106-e is provided as follows.  **Agreement**  Rel. 17 inter-cell MTRP, the maximum number of additional RRC -configured PCIs per CC is denoted X and can be reported as a UE capability   * For the report value of X, multiple candidate values including 1 is supported.   + FFS: Which values to support other than 1.   + Values larger than 7 are precluded   + RAN1 needs to agree on value(s) of X other than 1 * Down-select one of the following alternatives:   + Alt 1: A single value of X is reported as UE capability for any possible SSB time domain position and periodicity   + Alt 3: At least Two independent X values (X1, X2) are reported as a UE capability for at least two different assumptions on SSB time domain position and periodicity with respect to serving cell SSB * The serving cell PCI is always associated with active TCI states, only 1 additional PCI can be associated with the active TCI States   For AI 8.1.2.2, i.e., inter-cell mTRP operation, only one additional PCI different from the serving cell PCI can be associated with active TCI state(s) per CC. The related agreement made in RAN1 #104b-e is copied below.  **Agreement**   * For intercell MTRP operation, 1 additional PCI different from the serving cell PCI is supported per CC   + The additional PCI is the one associated with one or more TCI states that are activated for [CSI-RS for CSI]/PDSCH/PDCCH, per CC.   + Applicable at least for non-cross carrier QCL indication     - FFS: Cross carrier scheduling QCL indication * RAN1 to decide on the maximum number of PCIs different from the serving cell PCI per CC and/or across all CCs that can be RRC-configured for multi-DCI based inter-cell multi-TRP * Above should be specified by reusing R15 QCL rules as concluded in RAN1#104-e |

Table 11 Tdoc based companies’ inputs

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| LGE: For inter-cell mDCI based mTRP, more than one candidate TRPs with different PCI can be configured by RRC but only one can be activated by MAC-CE other than serving cell TRP. For inter-cell BM, the numbers configurable by RRC and to be activated by MAC-CE of TRPs with different PCI are not decided yet.  HW: The number of TRPs involved in the operation is not limited to two. RAN1 is discussing the supported number of RRC configured PCIs that is different from serving cell PCI (which is related to TRPs from which UE may send/receive data and TRPs from which the UE is to make L1 measurements) and will provide details to RAN2 when available.  OPPO: The TRPs involved in inter-cell beam management is serving cell TRP and one TRP with different PCI. The UE can be configured to operate L1-RSRP measurement and reporting on SSB of TRP with different PCI.  VIVO: the number of TRPs involved in the operation is restricted to two, however the max number of RRC configured TRPs with different PCI can be larger than 1 (still under discussion in RAN1)  ZTE: Regarding number of TRPs, the number of TRPs involved in the operation is restricted to two (i.e. serving cell TRP and TRP with different PCI). Also, till TCI state update, all of UE-dedicated channels/RS transmission/reception (including L1 measurement) should be performed at only one of serving cell TRP and TRP with different PCI, but non-UE dedicated channels/RSs transmission only can be performed in the serving cell TRP.  Xiaomi: [RAN1 reply]: The maximum number of TRPs with different PCI is 1 or up to UE capability with candidate values of 1 and X and will be decided in 106b-e meeting. If only 1 is supported, then the number will be restricted to two, otherwise any value no larger than (X+1) will do.  Intel: The maximum number of TRPs with different PCIs involved in inter-cell BM operation is dependent on the considered functionality (e.g., data transmission, L1 measurement, L1 reporting, etc.) and is typically determined by UE capability and NW configuration. In particular, for data transmission the maximum number of TRPs involved in inter-cell BM would be defined by the number of TCI states activated for the UE. At the same time, due to lack of simultaneous Tx/Rx operation in DL and UL for inter-cell BM, the actual transmission in a given time would be always limited to a single TRP only. For L1-RSRP measurements, the number of TRPs involved in inter-cell operation would be determined by the number of SSB with different PCID configured in CSI-ResourceConfig. The actual maximum number of TRPs with different PCID for which L1 measurements are reported would be limited to 4.  Samsung: RAN1 is still discussing the maximum number of RRC configured PCIs different from the serving cell for measurement and reporting and has made the following agreement  **Agreement**  On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, select NMAX(the maximum number of RRC configured PCIs different from the serving cell for measurement/reporting) from the following alternatives (to be decided in RAN1#106bis-e):   * Alt1: NMAXis up to UE capability with candidate values of 1 and X.   + Note: X as agreed in AI 8.1.2.2   + When NMAXis configured to be X, the UE measures up to X PCIs different from the serving cell PCI   + Additional restriction may be added by RAN4 * Alt2. NMAX=1   The related agreement made in AI 8.1.2.2 (inter-cell mTRP) during RAN1 #106-e is provided as follows.  **Agreement**  Rel. 17 inter-cell MTRP, the maximum number of additional RRC -configured PCIs per CC is denoted X and can be reported as a UE capability   * For the report value of X, multiple candidate values including 1 is supported.   + FFS: Which values to support other than 1.   + Values larger than 7 are precluded   + RAN1 needs to agree on value(s) of X other than 1 * Down-select one of the following alternatives:   + Alt 1: A single value of X is reported as UE capability for any possible SSB time domain position and periodicity   + Alt 3: At least Two independent X values (X1, X2) are reported as a UE capability for at least two different assumptions on SSB time domain position and periodicity with respect to serving cell SSB * The serving cell PCI is always associated with active TCI states, only 1 additional PCI can be associated with the active TCI States   For AI 8.1.2.2, i.e., inter-cell mTRP operation, only one additional PCI different from the serving cell PCI can be associated with active TCI state(s) per CC. The related agreement made in RAN1 #104b-e is copied below.  **Agreement**   * For intercell MTRP operation, 1 additional PCI different from the serving cell PCI is supported per CC   + The additional PCI is the one associated with one or more TCI states that are activated for [CSI-RS for CSI]/PDSCH/PDCCH, per CC.   + Applicable at least for non-cross carrier QCL indication     - FFS: Cross carrier scheduling QCL indication * RAN1 to decide on the maximum number of PCIs different from the serving cell PCI per CC and/or across all CCs that can be RRC-configured for multi-DCI based inter-cell multi-TRP * Above should be specified by reusing R15 QCL rules as concluded in RAN1#104-e   Nokia: For inter-cell beam management and inter-cell mTRP maximum of 1 additional PCI to serving cell is considered for reporting and being active for communication  Lenovo: For the data transmission/reception, because the number of CORESETPoolIndex is limited to 2, the number of TRPs used for data transmission/reception is 2 and each TRP corresponding to a CORESETPoolIndex value. However, for inter-cell measurements, the number of non-serving cells associated with the SSB resources in a CSI-Report for L1 measurement is still under discussion in RAN1.  Apple: Number of TRPs is up to UE capability with the minimal value of 1. There is no restriction on TRPs from L1 measurement perspective if there is no QCL-TypeD collision for SSBs from different cells overlapped in time.  QC: The number of TRPs involved in inter-cell BM is up to UE capability with candidate value under discussion. UE can receive/transmit both UE dedicated and common channels from/to serving cell TRP, while UE can only receive/transmit UE dedicated channels from/to non-serving cell TRP. The TRPs for L1 measurements are configured via RRC without additional restriction. For inter-cell mTRP, the number of non-serving cell TRPs associated with active TCI state(s) is always one, while the number of RRC configured non-serving TRPs (with different PCIs) is under discussion.  Ericsson: In mTRP, the UE can simultaneously receive from at most 2 TRPs. It should however be possible to RRC configure more than one additional TRP with a different PCI, since this will make the functionality significantly more useful – in fact relying on RRC to switch between makes the mTRP functionality quite cumbersome to use. It should also be possible to perform L1 measurements on several TRPs. The same is true for inter-cell beam management, with the additional restriction that UE-dedicated data can only be received from one TRP at a time. |

Table 12 Proposed reply to RAN2

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| e) **PCell/PSCell/SCell:** Is the inter-cell beam management applicable to any serving cell (i.e. PCell/PSCell/SCell)? That is, can intercell beam management or intercell mTRP be configured for SCell and/or PSCell in addition to PCell?  **Answer 2.e**: inter-cell beam management can be applicable to any serving cell (i.e. PCell/PSCell/SCell). |

Table 13 Tdoc based companies’ inputs

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| LGE: Yes, inter-cell BM and inter-cell mTRP are basically per BWP/CC operation so they can be applied for any serving cell (i.e. PCell/PSCell/SCell). For inter-cell BM, moreover, it is possible to update serving beam for multiple CCs simultaneously with single MAC-CE and/or DCI command analogous to Rel-16 multi-CC simultaneous TCI/spatial relation update.  HW: Yes  OPPO: Inter-cell beam management can be applicable to any serving cell  VIVO: unified TCI framework for inter-cell beam management applies for both PCell and SCell if they are in same band, however RAN1 has not discussed applicability of unified TCI framework for DC scenario. There is no restriction for inter-cell mTRP according to legacy TCI framework to support SCell and/or PSCell in addition to PCell.  ZTE: Regarding PCell/PSCell/SCell, RAN1 confirms that the inter-cell beam management can be applicable to any serving cell (i.e. PCell/PSCell/SCell).  Xiaomi: [RAN1 reply]: Yes, It is.  In RAN1#103-e meeting, the network architecture for inter-cell beam management is discussed and it is agreed that both NSA, i.e. LTE PCell and NR-PSCell, and SA are supported. Therefore, the inter-cell beam management is applicable to any serving cell (i.e. PCell/PSCell/SCell).  Samsung Yes, as long as for each cell on the serving cell, the corresponding neighboring cell with a different PCI is on the same frequency per the updated WID: “this work shall only consider intra-DU and intra-frequency cases”  Nokia: In release 17, inter-cell beam management is applicable only for PCell/  Lenovo: Both inter-cell beam management and inter-cell mTRP can be configured for a serving cell as a SCell as well as in PCell.  Apple: Inter-cell BM and mTRP are applicable to any serving cell.  Intel: There is no restriction on usage of PCell/PSCell/SCell for inter-cell beam management, i.e., the corresponding Rel-17 inter-cell BM functionality is applicable to any serving cells configured for the UE.  QC: For both inter-cell BM and inter-cell mTRP, it can be applicable to all cells: PCell, SCell, and PSCell. |

Table 14 Proposed reply to RAN2

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| f) **TCI switching signalling:** Which signalling should be used for TCI switching for inter-cell beam management?  **Answer 2.f**: Inter-cell beam management is going to use Rel-17 unified TCI signaling where RAN1 agreed that a MAC-CE activates one or multiple TCI states out of RRC configured TCI state pool. If multiple TCI states are activated, DCI selects one TCI state among activated ones. |

Table 15 Tdoc based companies’ inputs

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| LGE: For TCI switching via Rel-17 unified TCI signaling, RAN1 agreed that a MAC-CE activates one or multiple TCI states out of RRC configured TCI state pool. If multiple TCI states are activated, DCI selects one TCI state among activated ones.  HW: Both MAC-CE based and MAC-CE+DCI-based beam indication schemes are supported.   |  | | --- | | **Agreement**  On Rel.17 beam indication enhancements for inter-cell management, for the supported Rel-17 MAC-CE-based and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation):   * Both MAC-CE based and MAC-CE+DCI-based beam indication schemes are supported   Note: Previous agreement in RAN1#104b-e that remaining unused DCI fields and codepoints are reserved in R17 are not to be reverted. |   OPPO: The MAC CE + DCI signaling method of Rel-17 unified TCI framework is reused for inter-cell beam management.  VIVO: Both DCI, MAC CE signalling are supported for beam indication.  ZTE: Regarding TCI switching signalling, Rel-17 MAC-CE-based and/or DCI-based beam indication can be used for TCI switching for inter-cell beam management  Xiaomi: [RAN1 reply]: Both Rel17 MAC-CE based and Rel-17 MAC-CE+DCI-based beam indication schemes are supported for inter-cell mTRP.  Intel: As mentioned above inter-cell BM operation are supported using unified TCI framework. In this case TCI switching can be performed using either MAC-CE or DCI + MAC CE signalling.  Samsung: This based on the unified TCI framework, which uses both MAC-CE based and MAC-CE+DCI based beam indication schemes.  Nokia: For inter-cell beam management RAN1 has agreed that same rel-17 unified TCI state beam indication used for intra-cell beam management except for non-UE dedicated channels/signals. For inter-cell mTRP, the legacy beam indication framework is used.  Lenovo: TCI states used for inter-cell beam management are configured in RRC similar to intra-cell CSI report. MAC-CE can be used for TCI state activation for PDCCH and PDSCH, and DCI with format 1\_1/1\_2 can be used to indicate the single common TCI state to use for data/control transmission.  Apple: Both MAC CE and DCI are supported.  QC: Both MAC-CE based and MAC-CE+DCI based beam indication schemes are supported.  Ericsson: Here it is important to explain that DCI can be used to perform the switch, and that RAN1 has designed an acknowledged version of the DCI signalling, to improve robustness. Also, there will most likely be a mode of operation where the switch is performed using MAC CE only. |

Table 16 Proposed reply to RAN2

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| h) **Simultaneous Tx/Rx from and to “serving cell TRP” and “TRP with different PCI”:** Is it correct understanding that such simultaneous Tx/Rx is not supported for “inter-cell beam management”, but is supported for “inter-cell mTRP”? If so, what is the difference regarding their configuration that needs to be introduced by RAN2?  **Answer 2.h**: It is correct understanding that simultaneous Tx/Rx is not supported for inter-cell BM but supported for inter-cell mTRP. From configuration perspective, regarding the last question, inter-cell BM will be supported based on the unified TCI framework to be introduced in Rel-17 so relevant Rel-17 TCI configuration parameters will be required to enable this feature. Meanwhile inter-cell mTRP feature is to extend Rel-16 multi-DCI mTRP functionality to TRPs with different PCI so that its configuration parameters will be same or similar to Rel-16 CORESET pool related parameters. |

Table 17 Tdoc based companies’ inputs

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| LGE: For inter-cell mTRP, UE can receive two PDCCHs/PDSCHs associated with different CORESET pool index in overlapped symbol(s) but cannot transmit PUSCH/PUCCH to different TRPs at the same time. Accordingly, simultaneous Rx from serving cell TRP and TRP with different PCI is possible depending on whether two CORESET pool indices are configured but simultaneous Tx is not possible. For inter-cell BM, RAN2’s understanding is correct, i.e. simultaneous Tx/Rx from and to “serving cell TRP” and “TRP with different PCI” is not possible.  From configuration perspective, regarding the last question, inter-cell BM will be supported based on the unified TCI framework to be introduced in Rel-17 so relevant Rel-17 TCI configuration parameters will be required to enable this feature. Meanwhile inter-cell mTRP feature is to extend Rel-16 multi-DCI mTRP functionality to TRPs with different PCI so that its configuration parameters will be same or similar to Rel-16 CORESET pool related parameters.  HW: Yes, it is correct understanding that such simultaneous Tx/Rx is not supported for inter-cell beam management. For inter-cell mTRP, simultaneous Rx from “serving cell TRP” and “TRP with different PCI” is supported, but simultaneous Tx to “serving cell TRP” and “TRP with different PCI” is not supported. According the WID objective, inter-cell beam management and inter-cell mTRP are to be designed based on different TCI frameworks (Rel-17 unified TCI framework vs Rel-15/16 TCI framework), with which separate configurations can be considered by RAN2.  OPPO: Simultaneous Tx/Rx is not supported for Rel-17 inter-cell beam management. In inter-cell mTRP, simultaneous Rx from two TRPs for DL but not for UL.  VIVO: Yes, simultaneous Tx/Rx is not supported for inter-cell BM but simultaneous Rx is supported for inter-cell mTRP. Inter-cell mTRP transmission is based on Rel-16 M-DCI scheme whereas inter-cell beam management is based on unified TCI framework.  ZTE: Regarding Simultaneous Tx/Rx from and to “serving cell TRP” and “TRP with different PCI”, RAN1 confirms that such simultaneous Tx/Rx is NOT supported for “inter-cell beam management”, but is supported for “inter-cell mTRP”. Then regarding their configuration that needs to be introduced by RAN2, whether coresetPoolIndex is configured can be used for distinguishing “inter-cell beam management” and “inter-cell mTRP”.  Xiaomi: [RAN1 reply]: Yes. More discussion is needed for RNA1 to decide the difference regarding their configuration.  From our understanding, according to the report of UE capability, if UE supports multi-DCI based multi-TRP and support of fully/partially overlapping PDSCHs in time, the UE can be configured as inter-cell beam management or inter-cell mTRP. Otherwise, UE can only be set to inter-cell beam management.  As for the difference regarding their configuration, there will be at least two coresetPoolIndex associated with CORESET in case of inter-cell mTRP to inform UE multi-DCI based mTRP and only one coresetPoolIndex in inter-cell beam management.  Samsung: Yes, for inter-cell beam management at any time data can be received from one cell and can be transmitted to one cell. For inter-cell multi-TRP data can be received from multi-cells at the same time (e.g. on different beams) using the legacy Rel-15/Rel-16 TCI framework. To enable the simultaneous Tx/Rx for inter-cell mTRP, each PCI is associated with a different CORESETPoolIndex value. The related agreement made in AI 8.1.2.2 (inter-cell mTRP) during RAN1 #106-e is:  **Agreement**   * For inter-cell mTRP, one PCI associated with one or more of activated TCI states for PDSCH/PDCCH is associated with one *CORESETPoolIndex*, another PCI associated with one or more of activated TCI states for PDSCH/PDCCH is associated with another *CORESETPoolIndex* * FFS: The association between PCI and *CORESETPoolIndex* when switching between intra-cell mTRP and inter-cell mTRP   Nokia: A2h: For inter-cell beam management, for Rel-17 UE can be assumed to receive and transmit dedicated channels associated with the same PCI and receive common channels associated with the same PCI as serving cell. UE may not be capable of simultaneous reception of common and dedicated channels in this case.  A2h: For inter-cell mTRP, the reception and transmission assumptions follow the same behavior specified in Rel-15/Rel-16. Inter-cell mTRP requires (more than one value of) CORESETPoolIndex to be configured for operation.  Lenovo: Simultaneous TX from UE to different TRPs with different beams in a serving cell is not supported. Simultaneous RX from different TRPs in a serving cell is supported for both inter-cell beam management and inter-cell mTRP.  Apple: It is correct that simultaneous Tx/Rx is not supported for inter-cell BM but supported for inter-cell mTRP. Simultaneous reception is RAN1’s aspect and has nothing to do with RAN2’s configuration.  QC: Yes, it is correct understanding for simultaneous Rx, while simultaneous Tx is not supported for both inter-cell BM and inter-cell mTRP. The TCI state configuration is different compared to R17 unified TCI for inter-cell BM and R15/16 beam indication for inter-cell mTRP.  Intel: Simultaneous Tx/Rx transmission is only supported for downlink inter-cell mTRP operation. There is no simultaneous Tx/Rx operation (neither DL nor UL) supported for inter-cell beam management. |

Table 18 Companies’ inputs on the basic Tx/Rx operation with inter-cell beam management

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| **Company** | **Input** |
| Mod V0 | **Please share your inputs on the above (please refer to the above questions as question 2.a, 2.b, 2.c, 2.d, 2.e, 2.f, 2.h)**  **2.a: I suggest we try to agree in this meeting under which circumstances separate TCI indication would allow the transmission/reception of DL/UL to TRPs configured to different PCIs. Based on the submitted contributions, the majority of companies would support flexible operation.**  **2.b: a bit diverse views, a baseline answer is possible without further agreements.**  **2c: stable answers.**  **2d: this topic needs RAN1 discussion.**  **2e: stable answers.**  **2f: stable answers.**  **2h: converging answers.** |
| Samsung | For 2a: Reply is fine with the following update:  **Answer 2.a**: For inter-cell BM, there are two beam indication modes. One mode is called joint TCI, where DL and UL beams are always same. The other mode is called separate TCI, where DL and UL beams are independently indicated. For the separate TCI mode, RAN1 has not ~~decided whether~~ agreed to introduce such restriction that DL and UL beams should not be set to different TRPs with different PCIs.  2b to 2h agree with proposed replies. |
| Qualcomm | For 2.b, suggest the following clarification. To our understanding, both Q2 and 2b didn’t not explicitly say only asking inter-cell BM, and the LS title is for both features. So it may be good to compare both side by side, since RAN2 seems still not very clear on the difference.  **Answer 2.b**: system information and paging for inter-cell beam management can be only received from the serving cell TRP. For inter-cell BM, ~~W~~when receiving PDCCH/PDSCH with colliding QCL, prioritization rule specified in Rel-15/16 can be reused. For inter-cell mTRP, it is possible for UE to receive PDCCH/PDSCH with colliding QCL from two TRPs simultaneously.  For 2d, suggest to clarify the TRP # for operation for each feature as well. This is asked in the 2d, and to our understanding, both Q2 and 2d did not explicitly say only asking for inter-cell BM. The inter-cell BM answer can be revised based on future agreement.  **Answer 2.d**: RAN1 is still discussing the maximum number of RRC configured PCIs different from the serving cell for measurement and reporting and has made the following agreement. The number of non-serving cell TRPs associated with active TCI state(s) is always one for inter-cell mTRP, and is under discussion for inter-cell BM.  For 2f, suggest to add the following clarification  **Answer 2.f**: Inter-cell beam management is going to use Rel-17 unified TCI signaling where RAN1 agreed that a MAC-CE activates one or multiple TCI states out of RRC configured TCI state pool. If multiple TCI states are activated, DCI selects one TCI state among activated ones. If only one TCI state is activated, the activated TCI state is also implicitly selected without further DCI indication.  For 2h, suggest to clarify simultaneous Tx is not supported for both.  **Answer 2.h**: It is correct understanding that simultaneous ~~Tx/~~Rx is not supported for inter-cell BM but supported for inter-cell mTRP, while simultaneous Tx is not supported for both. From configuration perspective, regarding the last question, inter-cell BM will be supported based on the unified TCI framework to be introduced in Rel-17 so relevant Rel-17 TCI configuration parameters will be required to enable this feature. Meanwhile inter-cell mTRP feature is to extend Rel-16 multi-DCI mTRP functionality to TRPs with different PCI so that its configuration parameters will be same or similar to Rel-16 CORESET pool related parameters. |
| vivo | @Qualcomm, on 2b for inter-cell mTRP, UE can receive PDCCH/PDSCH with colliding QCL from two TRPs simultaneously but system information and paging are different. |

### **Reply on MAC aspects**

Based on the above inputs, the following reply is proposed:

Table 19 Proposed reply to RAN2 on MAC aspects

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| **Question 3:** RAN2 would like to understand the impacts to MAC operation, in particular:  a) **Timing advance:** Is it assumed that TA is the same for both *serving cell TRP* and *TRP with different PCI*, or does UE maintain different TAs for each?  **Answer 3.a**: In Rel 17 it is assumed that that a single TA is maintained by the UE for inter-cell beam management. The case of different TAs was discussed by RAN1 but no conclusion has been reached. |

Table 20 Tdoc based companies’ inputs

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| LGE: In Rel-17, RAN1 concluded that there is no consensus on introducing different TA across serving cell and TRPs with different PCIs from that of the serving cell based on the understanding that these features will be used only when propagation delay difference between TRPs is sufficiently small so that applying same TA value does not cause significant degradation on UL performance.  HW: RAN1 did not reach consensus on this in RAN1#106. We suggest RAN1 to discuss this in RAN1#106bis-e and provide an answer to RAN2.  OPPO: Same TA is assumed for both serving cell TRP and TRP with another different PCI.  VIVO: following conclusion is made in RAN1#106-e.  **Conclusion**  On Rel.17 enhancements for inter-cell beam management,   * In Rel-17, RAN1 cannot reach consensus in supporting same or different TA values across the serving cell and TRPs with different PCIs from that of the serving cell   ZTE: - Regarding Timing advance, RAN1 confirms that TA is the same for both serving cell TRP and TRP with different PCI, and UE only need to main one TAs for each.  Xiaomi: [RAN1 reply]: RAN1 cannot reach consensus in supporting same or different TA values across the serving cell and TRPs with different PCIs from that of the serving cell for inter-cell beam management.  Intel: RAN1 assumes the same TA for both serving cell TRP and TRP with different PCI according to RAN1#106e meeting agreement.  Samsung: This is the conclusion in RAN1:  **Conclusion**  On Rel.17 enhancements for inter-cell beam management,   * In Rel-17, RAN1 cannot reach consensus in supporting same or different TA values across the serving cell and TRPs with different PCIs from that of the serving cell   This implies that TA is left to NW implementation using the current specification. Naturally, this implies that the same TA value is used across cells/TRPs.  Nokia: UE assumes that single TA is maintained in Rel-17 inter-cell beam management  Lenovo: In R17 UE assumes the same TA applies to both serving cell TRP and non-serving cell TRP.  Apple: RAN1 has no consensus for UE to maintain multiple Tas  QC: For inter-cell BM there is no consensus in RAN1 on supporting different TAs for serving TRP and TRP with different PCI. For inter-cell mTRP only the single TA across TRPs is supported.  Ericsson: This has been discussed in RAN1 as well, but without any conclusion. Thus, there will not be any additions to the specification regarding TA handling. This means that the UE will only maintain a single TA. However, it is fully possible that the NW triggers a RACH transmission using a PDCCH order from the TRP with the other PCI. However, for this to work the TRP with the other PCI would have to be prepared to receive the PRACH using the serving cell configuration. |

Table 21 Proposed reply to RAN2 on MAC aspects

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| b) **RACH:** Are there any impacts to RACH operation with inter-cell beam management? That is, is it necessary to perform RACH toward TRP with different PCI e.g. for TA, BFR, etc?  **Answer 3.b**: There is no impact on RACH operation, i.e., RACH transmission should be performed by the UE to the serv-ing cell TRP. |

Table 22 Tdoc based companies’ inputs

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| LGE: As answered in a), there is no need to perform RACH toward TRP with different PCI for TA. For BFR, mTRP BFR is under discussion in different sub-agenda and mechanism to fall back to legacy RACH based BFR is under discussion for when both TRPs are in beam failure. As legacy RACH based BFR is not applicable in multi-cell scenario, same principle will be maintained in Rel-17.  HW: This partially depends on the outcome of question 3-a), i.e. TA. In addition, BFR is not explicitly included in the WID objective of inter-cell beam management in Rel-17. Given the limited time, we prefer not to enhance BFR for inter-cell beam management in Rel-17.  OPPO: There is no additional spec impact RACH operation in inter-cell beam management  VIVO: No.  ZTE: - Regarding RACH, there is no impacts to RACH operation with inter-cell beam management, only performed in the serving cell TRP.  Xiaomi: [RAN1 reply]: There is no need to perform RACH toward TRPs with different PCI to get the TA, because RAN1 cannot reach consensus in supporting same or different TA values. While as for the BFR, the recovery mechanism has not been discussed in RAN1. From my point of view, for inter-cell beam management, the periodic CSI-RS resources in provided by candidateBeamRSList or candidateBeamRSListExt-r16 only can be set to the RSs in serving cell, in which case the RACH toward TRP with different PCI is not necessary, or can be configured as the RSs in serving cell TRP and/or in the TRP with different PCI, in which case the RACH toward TRP with different PCI is needed. In sum, more discussion is needed to decide this question for RAN1.  Samsung No impact on RACH.  Intel: There is no impact on RACH operation, i.e., RACH transmission should be performed by the UE to the serving cell TRP.  Nokia: RACH is performed towards serving cell.  Lenovo: Firstly, RACH towards TRP with different PCI for TA is not needed since a same TA is applied to both TRPs. Secondly, BFR in SCell R16 can be performed for the BFR for TRP with a different PCI, so there is no need for RACH towards this TRP.  Apple: No  QC: For inter-cell BM, RAN1 did not reach the consensus on this issue. For inter-cell mTRP there is no change to legacy operation, i.e. RACH is configured only on PCell.  Ericsson: As we discussed above, there are no enhancements to the RACH handing. The NW can trigger a RACH procedure from the TRP with other PCI using a PDCCH order. However, RACH procedures that results from BFR or the expiration of the TA timer would be transmitted towards the serving cell, with a reduced probability of success. RRC reestablishment may also not be successful – in the unlikely event of radio link failure, the UE would go to Idle. |

Table 23 Proposed reply to RAN2 on MAC aspects

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| c) **UL PC/PHR:** When UE is configured for *TRP with different PCI* for a cell with UL, is there an impact to UL power control or PHR?  **Answer 3.c**: No impact on power control and PHR beyond what is needed to support multi-TRP in the same cell. |

Table 24 Tdoc based companies’ inputs

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| LGE: Inter-cell BM and mDCI based mTRP have no impact on PHR. Inter-cell mDCI based mTRP has no impact on power control as well. For inter-cell BM, there has been RAN1 agreements related to how to configure pathloss RS and power control parameters for UL TCI indication with Rel-17 TCI signaling framework, which will be informed to RAN2 together with other inter-cell BM agreements.  HW: This partially depends on the outcome of question 3-a).  OPPO: There is no additional spec impact on UL power control and PHR in inter-cell beam management.  VIVO: pathloss RS from TRP with different PCI can be configured.  ZTE: Regarding UL PC/PHR, in such case, the TCI-specific UL power control as agreed in Rel-17 can achieve independent UL power control and PHR for TRP with different PCI for a cell with UL as well.  Xiaomi: [RAN1 reply]: Because the spatial location of serving cell TRP and TRP with different PCI are totally different, the channels between UE and these two TRP have big difference. Therefore, at least the pathloss reference signal to estimate the uplink path loss should be configured as one reference signal of TRP with different TRP when UE is configured for TRP with different PCI for a cell with UL.  Samsung No impact on power control and PHR beyond what is needed to support multi-TRP in the same cell.  Nokia: PUSCH power control and PHR are calculated based on the TRP (serving cell/other PCI) used for PUSCH  Lenovo: The only difference is the PL-RS is configured directly or indirectly to a SSB with a different PCI. Otherwise, there is no difference between intra-cell and inter-cell UL PC.  Apple: No.  QC: The UL PC/PHR has not been discussed in RAN1 for inter-cell BM. For inter-cell mTRP there is no change wrt Rel-15.  Intel: Power control for inter-cell beam management would be part of unified TCI framework. To support such functionality, PL RS in that framework should be linked to SSB that has PCID different from the serving cell PCID. |

Table 25 Companies’ inputs on the MAC aspects

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| **Company** | **Input** |
| Mod V0 | **Please share your inputs on the above (please refer to the above questions as question 3.a, 3.b, 3.c)**  **3a: stable answers, RAN1 decision in place.**  **3b: stable answers**  **3c: discussion needed!** |
| Samsung | 3a to 3c agree with proposed replies. |
| Qualcomm | Fine for 3a to 3c |
| vivo | Ok with proposed answers |

### **Reply on HARQ operation**

Based on the above inputs, the following reply is proposed:

Table 26 Proposed reply to RAN2 on HARQ operation

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| **Question 4:** How does the HARQ operation work with the multi-beam operation? In particular:  a) **HARQ entity:** Is there a single HARQ entity handling both the *serving cell TRP* and *TRP with different PCI*?  **Answer 4.a**: RAN1 assumes a single HARQ entity is used for both the serving cell TRP and TRP with different PCI. |

Table 27 Tdoc based companies’ inputs

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| LGE: RAN1 assume that there is a single HARQ entity for both TRPs  HW: Yes.  OPPO: From the perspective of RAN1, we do not see the impact on HARQ operation from inter-cell beam management i.e. on HARQ entity is assumed.  VIVO: single HARQ entity  ZTE: Regarding HARQ entity, RAN1 confirms that there is a single HARQ entity handling both the serving cell TRP and TRP with different PCI.  Xiaomi: [RAN1 reply]: RAN1 tends to support single HARQ entity for both inter-cell beam management and inter-cell mTRP.  RAN1 prefers to extend the HARQ-ACK feedback mechanism for intra-cell mTRP specified in Rel16 to inter-cell mTRP. And there is only single HARQ entity accordingly.  While for inter-cell beam management, both single HARQ entity and different HARQ entity corresponding to different TRP can be supported. However, because only intra-DU and intra-frequency scenarios will be considered in Rel17, RAN1 tends to support single HARQ entity for inter-cell beam management.  Samsung Yes. Please note that inter-cell beam management for intra-DU scenarios.  Nokia: RAN1 assumes single HARQ entity is used for both TRPs.  Lenovo: Same as multi-DCI multi-TRP in R16, they are handled by a single HARQ entity.  Intel: For multi-beam operation single HARQ entry is assumed handling both serving cell TRP and TRP with different PCI. In this case, the same HARQ process may continue after beam switching to another cell.  Apple: It is up to gNB implementation.  QC: This issue was not discussed in RAN1 for inter-cell BM. For inter-cell mTRP there is a single HARQ entity across TRPs.  Ericsson: There would be a single HARQ-entity, just as in the intra-cell operation. For mTRP, we would reuse the CORESETPoolIndex to manage the HARQ feedback. |

Table 28 Proposed reply to RAN2 on HARQ operation

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| b) **HARQ retransmissions:** Can retransmission occur from different TRP than initial transmission for the same HARQ process? E.g. can initial transmission be done from *serving cell TRP* and retransmission from *TRP with different PCI*?  **Answer 4.b**: Due to assumption on the same HARQ entity, it is possible to have initial transmission and re-transmission originating from TRPs with different PCIDs. |

Table 29 Tdoc based companies’ inputs

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| LGE: For mDCI based mTRP operation, both separate and joint A/N modes are supported in Rel-16, applicable for TRPs with same PCI. For TRPs with different PCI being considered in Rel-17, it has not been decided whether to support both A/N modes. If joint A/N is supported by assuming ideal backhaul between TRPs with different PCI, initial transmission and retransmission from different TRP with different PCI is possible. For inter-cell BM, RAN1 has not discussed/decided this issue yet.  HW: Yes.  OPPO: Inter-cell beam management has no impact on HARQ operation. The initial HARQ transmission and re-transmission during inter-cell beam management can be from same or different TRP.  VIVO: yes  ZTE: - Regarding HARQ retransmissions, RAN1 confirms that retransmission can occur from different TRP than initial transmission for the same HARQ process.  Xiaomi: [RAN1 reply]: For inter-cell mTRP, because we prefer to extend the HARQ-ACK feedback mechanism for intra-cell mTRP to inter-cell mTRP, the retransmission should be performed at the same TRP with that of initial transmission. While for inter-cell beam management, more discussion is needed to decide this question. Because the serving cell TRP and TRP with different is controlled by same MAC layer in case of intra-DU, RAN1 tends to support that the retransmission can occur from different TRP than initial transmission for the same HARQ process for inter-cell beam management.  Samsung Yes. Please note that inter-cell beam management for intra-DU scenarios.  Nokia: RAN1 assumes no restriction on HARQ retransmissions.  Lenovo: Since they are handled by the same HARQ entity, this is possible.  Intel: Due to assumption on the same HARQ entity, it is possible to have initial transmission and re-transmission originating from TRPs with different PCIDs.  Apple: Retransmission can occur from different TRP.  QC: This issue was not discussed in RAN1 for inter-cell BM. For mTRP, ReTx on different TRP is based on UE capability, I.e. there is no change wrt Rel-16.  Ericsson: Just as in intra-cell operation, there is no restriction from what TRP the different HARQ retransmissions come. The fact that different TRPs broadcast different PCIs will not change the situation. |

Table 30 Companies’ inputs on HARQ operation

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| **Company** | **Input** |
| Mod V0 | **Please share your inputs on the above (please refer to the above questions as question 4.a, 4.b)**  **4a: similar views but discussion/decision needed to endorse the operation mode.**  **4b: similar views but discussion/decision needed to endorse the operation mode.** |
| Samsung | 4a and 4b agree with proposed replies. |
| Qualcomm | For 4.b, suggest to add the following clarification.  **Answer 4.b**: Due to assumption on the same HARQ entity, it is possible to have initial transmission and re-transmission originating from TRPs with different PCIDs. At least for inter-cell mTRP, reTx on different TRP is based on UE capability, i.e. no change w.r.t. R16. |
| vivo | Fine with clarification from Qualcomm on 4b |

### **Reply on physical layer configuration**

Based on the above inputs, the following reply is proposed:

Table 31 Proposed reply to RAN2 on Physical layer configuration

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| **Question 5:** Does the *TRP with different PCI* have an independent physical layer configuration, e.g. for PUSCH/PDSCH/PDCCH/PUCCH and PRACH?  **Answer 5**: There is only one physical layer configuration and that is applied to all the PUSCH/PUCCH/PDSCH/PDCCH associated with TCI state that is associated with either serving cell PCI or another different PCI. Regarding the PRACH transmission, since no common channel can be received from TRP with a different PCI, the association between PRACH preamble and SSB should only occur for SSB of serving cell TRP. Therefore, there is no configuration of PRACH for the TRP with different PCI. |

Table 32 Tdoc based companies’ inputs

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| HW: No. As stated in the WID objective, the serving cell remains unchanged. In addition, targeting at intra-frequency scenario, RAN1 agreed to introduce QCL rule from <PDCCH/PDSCH of serving cell> to <CSI-RS of serving cell> and then to <SSB with PCI that is different from serving cell> (highlighted below), where the underlying assumption is that there will be no independent physical layer configurations.  OPPO: There is only one physical layer configuration and that is applied to all the PUSCH/PUCCH/PDSCH/PDCCH associated with TCI state that is associated with either serving cell PCI or another different PCI. Regarding the PRACH transmission, since no common channel can be received from TRP with a different PCI, the association between PRACH preamble and SSB should only occur for SSB of serving cell TRP. Therefore, there is no configuration of PRACH for the TRP with different PCI.  ZTE: Regarding Physical layer configuration, the TRP with different PCI does NOT have an independent physical layer configuration, e.g. for PUSCH/PDSCH/PDCCH/PUCCH and PRACH. |

Table 33 Proposed reply to RAN2 on Physical layer configuration

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| a) **Configuration differences:** Does RAN1 assume that only certain parameters can be different from the serving cell and if so, which ones?  **Answer 5.a**: RAN1 has not discussed or concluded to provided configurations for PUSCH/PDSCH/PDCCH/PUCCH and PRACH for TRP with different PCI. |

Table 34 Tdoc based companies’ inputs

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| LGE: Yes, RAN1 assumes that only certain parameters can be different. Major difference will be the QCL source RS configuration, which is configured by TCI state. In order to extend operation for TRPs with different PCI, RAN1 agreed to support configuring SSB resources with different PCI which can be used as QCL source RS for the UE. PDSCH/PUSCH configuration does not necessarily be independent because TRP switching can be done by switching QCL resource RS. Same principle can be applied for PUCCH/PDCCH for inter-cell BM, i.e. switching TCI for the PUCCH/PDSCH. For inter-cell mTRP, PUCCH and PDCCH configuration are independent for each TRP to support independent scheduling. For PUCCH, each TRP can use different portion of PUCCH resources. For PDCCH, each TRP uses different CORESET pool.  HW: Yes. For inter-cell beam management, the SSB used for TCI indication may have a PCI that is different from the serving cell. Note that though the higher layer signalling may allow for various kinds of configurations, the supported QCL rules are explicitly captured in RAN1 specs.  OPPO: The same configuration of PDCCH/PDSCH/PUSCH/PUCCH is applied to both TRPs and the PRACH configuration is not applicable to TRP with different PCI.  VIVO: RAN1 has not discussed or concluded to provided configurations for PUSCH/PDSCH/PDCCH/PUCCH and PRACH for TRP with different PCI.  ZTE: Regarding Configuration differences, the serving cell TRP and TRP with different PCI can be represented by two different groups of TCI states. Only TCI states corresponding to TRP with different PCI should be associated with non-serving cell information, involving different PCI, SSB time domain location, SSB periodicity and SSB transmission power.  Xiaomi: [RAN1 reply]: For both inter-cell mTRP and inter-cell beam management, we cannot assume that physical layer configuration of both TRP, which are serving cell TRP and TRP with different PCI, are always the same. Even for the intra-cell mTRP in Rel16, the CORESET for each TRP are configured respectively and the PDSCH/PUSCH of each TRP is scheduled by its own PDCCH. At least, the SCS and pathloss reference signal may be different. And RAN1 needs more discussion to determine the exact parameters that are different for serving cell TRP and TRP with different TRP.  Samsung: No assumptions made in RAN1, other than having a different PCI.  Nokia: L1 CSI measurement and reporting are configured by RRC. See RRC parameter list.  Lenovo: From UE point of view, its serving cell is not changed. So the same parameters apply.  Apple: No different parameters is needed  QC: RAN1 concluded that TCI state among serving cell TRP and non-serving cell TRP can be different; Other configuration parameters were not discussed. For inter-cell mTRP there is no change wrt Rel-16 multi-DCI framework.  Intel: The same configuration of PUSCH/PDSCH/PDCCH/PUCCH and PRACH is assumed for serving cell TRP and TRP with different PCI, i.e., no modification of the physical layer parameters is expected after switching between TRPs with different PCIDs. |

Table 35 Proposed reply to RAN2 on Physical layer configuration

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| b) **Configuration of inter-cell beam management measurements and reporting:** Which RRC configuration(s) need to be provided for inter-cell beam measurement and reporting? ‎  **Answer 5.b**: RAN1 just started RRC parameter discussion. |

Table 36 Tdoc based companies’ inputs

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| LGE: RAN1 just started RRC parameter discussion and will send a separate LS after RAN1#106bis-e meeting.  HW: RAN1 will provide recommended RRC parameters for inter-cell beam measurement and reporting together with RRC parameters required for other features.  OPPO: In RRC, some TCI states are associated with PCID different from that of the serving cell and a SSB associated with non-serving cell PCID is used as indirect QCL source in such TCI state. The UE can be configured to measure a set of SSBs associated with a non-serving cell PCID.  - For inter-cell beam management measurement and reporting, in RRC, the UE can be configured with L1-RSRP measurement and reporting on SSBs associated with a PCI different from that of the serving cell.  VIVO: at least SSB from TRP with different PCI should be provided for inter-cell beam management and reporting.  ZTE: Regarding Configuration of inter-cell beam management measurements and reporting, inter-cell beam measurement and reporting can be performed based on the legacy CSI framework, except that new SSB-Index\_r17 containing (above-mentioned non-serving cell information, SSB-index) in CSI-SSB-ResourceSet should be introduced.  Xiaomi: [RAN1 reply]: At least the RS configurations of TRP with different PCI used for beam measurement should be provided for inter-cell measurement/reporting.  Samsung: Information about SSBs of neighboring cell with different PCI need to be provided. Further details on RRC configurations will be included in the RRC parameter list.  Nokia: L1 CSI measurement and reporting are configured by RRC. See RRC parameter list.  Lenovo: Inter-cell beam measurement and reporting can be configured in CSI-ReportConfig. Only L1-RSPR from SSB with different PCI can be configured for inter-cell beam reporting.  Apple: It is based on legacy CSI framework, which is CSI-reportConfig.  QC: L1 measurement and reporting configuration for both inter-cell BM and inter-cell mTRP.  Intel: For inter-cell beam measurement and reporting, UE is expected to be provided with CSI resource configuration (CSI-ResourceConfig) that includes configuration of SSB resources associated with PCIDs which may be different from the serving cell PCID. |

Table 37 Proposed reply to RAN2 on Physical layer configuration

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| c) **Feature differences:** Are the RRC parameters/configurations different for inter-cell mTRP and inter-cell beam management?  **Answer 5.c**: Inter-cell beam management uses the unified TCI framework, inter-cell mTRP uses the legacy Rel-15/Rel-16 TCI framework. RRC parameters for configuring each of these frameworks is different. Further details on RRC configurations will be included in the RRC parameter list. |

Table 38 Tdoc based companies’ inputs

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| LGE: c) It may have common RRC parameters for SSB information with different PCI. The difference is whether SSB with different PCI is associated with Rel-17 unified TCI state for beam management or associated with Rel-16 TCI state for inter-cell mTRP since inter-cell mTRP is applied based on Rel-16 TCI framework.  HW: Yes.  OPPO: - The inter-cell BM and inter-cell mTRP follows same or different parameter/configurations as follows:  o For the L1-RSRP beam measurement and reporting: they follow the same configuration.  o For the TCI state configuration and indication: inter-cell BM follows Rel-17 unified TCI framework but the inter-cell mTRP follows the Rel-16 beam management.  o For the configurations related with control and data channels: inter-cell BM follows the configuration of single-TRP as specified in Rel-15 and inter-cell mTRP follows the configuration of multi-TRP as specified in Rel-16.  VIVO: TCI framework applicable for inter-cell mTRP and inter-cell beam management are different, however from RAN1 perspective some of the RRC configurations/parameters can be common, e.g. association of TCI state with PCI other than serving cell PCI, it is up to RAN2 to design considering flexibility, overhead etc. into account.  ZTE: Regarding Feature differences, RAN1 confirms that some RRC parameters/configurations for inter-cell mTRP and inter-cell beam management may be different. For instance, coresetPoolIndex is dedicated to inter-cell mTRP.  Xiaomi: [RAN1 reply]: Not all the RRC parameters/configurations of inter-cell beam management are same with that of inter-cell mTRP. At least the configuration of coresetPoolIndex associated with CORESET is different.  Samsung: Inter-cell beam management uses the unified TCI framework, inter-cell mTRP uses the legacy Rel-15/Rel-16 TCI framework. RRC parameters for configuring each of these frameworks is different. Further details on RRC configurations will be included in the RRC parameter list.  Nokia: Most parameters are the same but there are some differences. See RRC parameter list.  Lenovo: Inter-cell mTRP is configured for the data transmission, while inter-cell beam management is being specified to support DPS operation among different TRPs or inter-cell mTRP transmission. Different RRC parameter sets should be configured for different procedures, and there is no conflict between them.  Apple: Yes. Rel-17 inter-cell BM is based on unified TCI framework, while Rel-17 inter-cell mTRP is based on Rel-16 TCI framework.  QC: Beam indication configuration is different for inter-cell BM and inter-cell mTRP. Additionally, CORSET pool index config is required for mTRP.  Intel: The RRC parameters used for inter-cell mTRP and inter-cell beam management are expected to be different due to support of different TCI indication framework, i.e., Rel-16 TCI / spatial relation and Rel-17 unified TCI respectively. Configuration of inter-cell measurement and reporting for inter-cell BM and mTRP are the same. |

Table 39 Companies’ inputs on the applicability of Physical layer configuration

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| **Company** | **Input** |
| Mod V0 | **Please share your inputs on the above**  **5a: needs discussion and decision in RAN1**  **5b: needs discussion and decision in RAN1**  **5c: needs discussion and decision in RAN1** |
| Samsung | For 5: PRACH it might be better to discuss more, before making a conclusion. PRACH can be used for PDCCH order, BFR, in addition other dedicated PRACH configuration used cases.  **Answer 5**: There is only one physical layer configuration and that is applied to all the PUSCH/PUCCH/PDSCH/PDCCH associated with TCI state that is associated with either serving cell PCI or another different PCI. Regarding the PRACH transmission, ~~since no common channel can be received from TRP with a different PCI, the association between PRACH preamble and SSB should only occur for SSB of serving cell TRP. Therefore, there is no~~ RAN1 has not discussed configuration of PRACH for ~~the~~ a TRP with different PCI.  5a to 5c agree with proposed replies. |
| Qualcomm | For 5b, we think it is safe to say at least measurement/report config should be provided.  **Answer 5.b**: ~~RAN1 just started RRC parameter discussion.~~ L1 measurement and reporting configuration for both inter-cell BM and inter-cell mTRP. |
| vivo | For 5b, the answer can be revised based on RRC parameter discussion |