**Pre-RAN1#105-e offline discussion on issue 1 of multi-beam enhancements**

## QCL for CA

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| 1.8 | [Based on offline discussion, cf. Yuki, *reformulated for better clarity*] Carrier aggregation  For TCI state(s) shared across a set of CCs (that is associated with the same gNB beam):   * Alt1: CC-specific QCL-TypeD RS can be determined from the shared TCI state(s). The determined QCL-TypeD RSs for the set of CCs are further associated with a same QCL-TypeD RS. * Alt2: A single QCL-TypeD RS is determined from the shared TCI state(s), and support enhanced QCL chain: support “i) only”, “ii) only”, or “both i) and ii)” from the following:   + i) the QCL type A TRS and, if any, QCL type D TRS, in the same/different CSI-RS resources   + ii) the QCL type A TRS and, if any, QCL type D SSB | **Alt1 (11)**: Nokia/NSB, NTT Docomo, Intel, Apple, APT/FGI, CATT, Huawei/HiSi, Ericsson  **Alt2 (8)**: vivo, Samsung (OptA and B), ZTE, MTK, Sony (OptA only), Qualcomm (OptA and B), Spreadtrum, OPPO (OptA only) |

From the latest discussion moderated by Yuki (Alt1/2 description from x3559, I edited this to avoid using “common TCI” per Xi’s previous comment):

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| For QCL-Type D configuration in TCI state(s) shared across a set of CCs (that is associated with the same gNB beam):   * **Alt1**: Separate QCL-Type D RS for each of the CCs can be determined from the TCI state(s). The determined QCL-Type D RSs for the set of CCs are further associated with a same QCL-Type D RS. * **Alt2**: A single QCL-Type D RS for the set of the CCs is determined from the TCI state(s), and support enhanced QCL chain:   + Alt.2-1: Support Opt. A only.   + Alt.2-2: Support Opt. B only.   + Alt.2-3: Support both Opt. A and Opt. B.   Options of the enhanced QCL chain:   * Opt. A: The QCL-Type A TRS and, if any, QCL-Type D CSI-RS, with different CSI-RS resources. * Opt. B: The QCL-Type A TRS and, if any, QCL-Type D SSB.   ---  Example of QCL chain for both Alt.1 and Alt.2 are illustrated in the below Fig.1-2. Alt.1 has no impact on Rel.15 QCL chain, and Alt. 2 will introduce the new QCL chain (red allows in Fig.2).    Figure 2-1: Example of QCL chain of Alt. 1 (same QCL chain as Rel.15)    a) Opt. A b) Opt. B  Figure 2-2: QCL chain of Alt. 2 (Red part is new QCL chain from Rel.15)  As commented by Yushu, when we select from the Alt.1 and Alt.2, we should also consider RLM/BFR. Note that usually RLM/BFD RS are not RRC configured, and implicitly derived as “Type D RS for CORESET”, otherwise it is not possible to update RLM/BFD RS by MAC CE). Alt.1 has no problem on this (because the QCL chain is the same as Rel.15).  In Alt. 2,   * RLM: as long as “Single QCL-TypeD RS” is configured on PCell/PSCell, we can derive PCell/PSCell RS as RLM RS. (seems no problem) * BFD: if we assume “Single QCL-TypeD RS” is configured on PCell/PSCell, all SCell BFD RSs are implicitly derived as the same PCell/PSCell RS. So, it seems SCell BFR does not work in Alt. 2. (Note: in the QCL chain of Alt. 2 in Fig.2, BFD RSs of all SCells are implicitly derived as TRS on CC#0 (PCell/PSCell).) |

Table 1 Companies’ inputs: QCL for CA

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| **Please share your view on the following questions**   * **Q1. What’s your view on/response to Yushu’s argument on RLM/BFR in favor of Alt1?** * **Q2. Given that it is not very likely to support new QCL chaining rules in Rel-17 (OptA and OptB), can Alt2 proponents accept Alt1? If not, what’s the reason?** | |
| **Company** | **Input** |
| MediaTek | On Q1, to our understanding, when NW configures “common beam operation” for a set of intra-band CCs, UE will apply the same Rx beam for control channels in all of the configured CCs all the time. We are wondering separate BFRs are still needed for these configured CCs even they share identical beam operation? It seems SCell BFR is not quite useful for this case.  On Q2, due to the above understanding, we still prefer Alt2 with least Opt. A. Since using TRS as TypeD source RS is already support in Rel-15/16, we don't see implementation issue on this. |
| OPPO | Q1: Re the issue of RLM/BFR, Alt2 with single QCL-TypeD RS seems no problem for RLM/BFR. Actually, Alt2 with single QCL-TypeD RS can even reduce the UE complexity for beam failure detection because the UE monitor the same BFD RS for all the CCs.  Q2: We are ok with Alt2 but the Opt.A need to be revised as follows:   * Opt. A: The QCL-Type A TRS and, if any, QCL-Type D ~~TRS~~ CSI-RS, in ~~the same/~~different CSI-RS resources.   The reason for deleting “the same”: for one CC, the QCL-Type A TRS must be in that CC. Thus if the same CSI-RS is used for both QCL-TypeA and TypeD, it is impossible to support “single QCL-Type D RS for the set of the CCs” |
| Ericsson | Just for clarification, we have not agreed that the TCI states can be shared across CCs, have we?  Q1: It would seem that Alt2 is not complete. We also have the FR1-FR2 CA case, where there is no QCL-TypeD on the PCell.  Q2: Overall, the Rel-15 solution with TCI states defined per serving cell works fine. There seems to be little point in changing that how the TCI states are defined. |
| Samsung | Q1: With a common beam across a group of CCs (that can share the same beam, i.e. TCI state with QCL Type-D), it would seem natural to use the same RS for BFD in all CCs. As Oppo pointed out, this could save UE complexity, it also saves overhead. For SCell BFR, the underlying assumption is that a separate beam is used in each cell and hence the need for a separate BFD RS associated with each cell.  Q2: Given the argument in Q1, using a common QCL Type D source RS for a group of CCs sharing the same beam can reduce UE complexity, as the UE tracks only a single RS for the set of carriers. Therefore, we support Alt 2. Opt B seems to require an additional QCL Type D relation (for the SSB to be a source RS for PDSCH/PDCCH), therefore, we should at least support Opt A, we also like to be able to support Opt B. |
| Mod V5 | Modified Opt A per OPPO’s comment.  Re Ericsson’s question, we have the following agreement (in short, TCI states could differ across CCs but they would ultimately refer to the same QCL Type-D RS – cf. Alt1 (either directly or indirectly)):  On Rel-17 unified TCI framework, support common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs:   * ... * Just as Rel.16, the RS in the TCI state that provides QCL-TypeA [or QCL-TypeB] shall be in the same CC as the target channel or RS * The common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs * … |
| MediaTek | Re the modified Opt. A, we agree that “the same” should be deleted. But does changing “QCL-Type D TRS” to “QCL-Type D CSI-RS” mean any type of CSI-RS (BM, TRS, or CSI) can be supported as TypeD source in Opt.A? |
| Apple | We support Alt1.  For Alt2 OptA and OptB, in addition to the RLM/BFD issues, it is possible the beam for source RS for QCL-TypeA indication and QCL-TypeD indication are with different, which would complicate UE implementation. |
| Docomo | We support Alt.1.  Re the modified Opt. A, we don’t agree that “the same” should be deleted. Strictly speaking, for a CC with QCL-type D RS, QCL type A RS and QCL type D RS should be the same; for other CCs, QCL type A RS and QCL type D RS should be different. (Note: There is no need to assumer different QCL type A RS and QCL type D RS on a CC with QCL type D RS)  We don’t understand clearly why Alt.2 can save UE complexity. Alt.1 assumes the common root SSB as QCL type D source of TRS on each CCs. UE can determine Rx beam based on the root SSB reception. This is also aligned with TS38.133. TS38.133 says when UE is indicated new TCI state by MAC CE, UE shall wait next SSB reception to apply the new TCI state, which means UE is allowed to wait next root SSB reception to determine Rx beams.  We also need to discuss the issue of Alt.2 which Ericsson raised: *We also have the FR1-FR2 CA case, where there is no QCL-TypeD on the PCell*. We also don’t understand how Alt.2 works in FR1-FR2 CA. |
| Huawei, HiSilicon | 1. “TCI state(s) shared across a set of CCs” have not been agreed. What was agreed is to use “common TCI state ID update”. We suggest revising Alt1 as below to make this clear.   * Alt1: CC-specific QCL-TypeD RS can be determined from the ~~shared~~ indicated common TCI state~~(s)~~ ID. The determined QCL-TypeD RSs for the set of CCs are further associated with a same QCL-TypeD RS.   2. We failed to understand how Opt A/B under Alt-2 can provide a technical advantage over Alt-1. If it is about UE complexity/overhead for BFD, the NW can simply choose not to configure SCell BFR. In our view, going with Opt A/B under Alt-2 will add extra complexity to UE, as it will now need to handle different sources for QCL TypeA and TypeD.  3. In our understanding, for CA within an FR2 band, as the two CC(s) can be distantly separated (e.g., 700MHz) and gNB may use different Tx panel/beam(s) to transmit different CC(s), there is use case to configure SCell BFR when the UE is expected to apply the same Rx beam to receive multiple CC(s).  4. The comment/question from Ericsson/DOCOMO on FR1+FR2 CA is also valid. In this case, TCI states for FR1 CC(s) and FR2 CC(s) are typically different, and it is not well-motivated to “share” TCI states across CC(s). |
| Sony | Regarding Q1, we think the answer from OPPO and Samsung could address the question. Instead of monitoring BFD RS per BWP per CC, if one single BFD RS on a CC can be shared among multiple CCs, UE’s complexity on measuring BFD RS (at least from this aspect) can thus be reduced.  As for Q2, since Q1 seems not insolvable question, we would stick to Alt 2-1. Moreover, we share the same view with Docomo that for Opt. A, there is one case (circled in figure below) that QCL-TypeA RS and QCL-TypeD RS could be the same RS on a CC.    For FR1-FR2 CA case, we tend to agree that QCL-TypeD RS on PCell (FR1) is typically not suitable to provide spatial Rx reference to other CCs (FR2). From this sense, Alt.1 seems a better choice, with common root SSB cut off as below. Specifically, one common TCI state ID in each CC points to different TCI states. It looks like (perhaps I am wrong) we are not stepping forwarding and just reusing Rel.16 X-CC beam indication mechanism.    As for Alt.2, hopefully NW would not make such configuration. |
| ZTE | Regarding Q1, we share the same views with Sony, OPPO and Samsung that the UE can share the same BFD-RS in such case, like CC-group specific BFR with a transparent manner.  Regarding Q2, we strongly support Alt2 due to the fact that we have the following agreement. Using a same/single RS as for determining spatial relation should be a basic principle for unified TCI framework. It seems to revert this agreement if going with Alt1, to be honest.  On Rel-17 unified TCI framework, support common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs:   * ... * Just as Rel.16, the RS in the TCI state that provides QCL-TypeA [or QCL-TypeB] shall be in the same CC as the target channel or RS * The common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs * …   If really need to go with Alt-1, as a compromise, we think that a single RRC pool of TCI states should be supported for CA case for saving the gNB RRC configuration overhead and UE memory/storage. We do not want to make the duplicated TCI configuration in all CCs. |
| Samsung2 | Regarding the reduced complexity of Alt2, it comes from the fact that a single RS is being signaled to the UE to use for the determination of the spatial filter across a set of CCs. The UE determines a beam once for the set of CCs. Alt1 requires a separate source RS to be signaled for each CC, even if these source RSs are QCLed to the same source RS, they could be in fact using narrower beams within the beam of root source RS, this could require the UE to determine separate spatial filters for each CC (to optimize its implementation), hence the higher complexity. The figure below is a simple illustration of this point.    Regarding CCs in FR1 and FR2, we think that they will not be in the same set of CCs that is indicated a common beam. In this case, the source RS for FR2 can be different from that of FR1. In fact, for FR1, there is no QCL Type D source RS.  We agree with ZTE, that Alt1 implies reverting the agreement made in a previous meeting. Having a separate source RS for each CC, even with the same root source RS, is not the same as having “the **same/single** RS determined according to the TCI state(s) indicated by a common TCI state ID” However, to move forward if there is majority support for Alt1, we can accept Alt1, as long as a single RRC pool of TCI states is supported for CA as suggested by ZTE. |
| Docomo | Alt. 1 says “*The determined QCL-Type D RSs for the set of CCs are further associated with a same QCL-Type D RS.*” So, we don’t need to revert the agreement which ZTE/Samsung mentioned.  As ZTE and Samsung commented, we also believe a single RRC pool of TCI state with Alt.1 is a good compromise. Hence, we support it.  We still believe Alt.2 has an issue in FR1-FR2 CA. Usually, we don’t configure QCL-Type D RS in FR1. Thus, the single QCL-type D RS cannot be shared in FR1-FR2 CA. |
| Mod V15 | Based on the above inputs, Alt1 (with minor wording clarification from Huawei) + a single TCI state pool across CCs (pointed out by ZTE) is a good compromise to resolve this sticky situation. **Please see the ‘offline FL proposal 1’ below and share your comments, if any.**   * A note citing the previous agreement is added to clarify how the common TCI state ID is related to the use of a same QCL-TypeD RS   **I will use the proposal below (the final form in this offline discussion) in my round FL summary.** |
| **Offline FL proposal 1**: On Rel.17 unified TCI framework, for QCL-Type D configuration in TCI state(s) shared across a set of CCs (that is associated with the same gNB beam)   * CC-specific QCL-TypeD RS can be determined from the indicated common TCI state ID. The determined QCL-TypeD RSs for the set of CCs are further associated with a same QCL-TypeD RS.   + Note: From a previous agreement, the common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs * A single RRC pool of TCI states is used for the set of CCs | |
| MediaTek | Okay to support single TCI pool but with CC-specific QCL-TypeD RS as a compromise, we prefer to reformulate the proposal 1 as follows. Meanwhile, how to determine the CC-specific RS for QCL-TypeA RS, which is agreed in RAN1#103, can be also included in this proposal, if needed.  Offline FL proposal 1: On Rel-17 unified TCI framework, a single RRC pool of TCI states is used for common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs:   * CC-specific ~~QCL-TypeD~~ RS can be determined from the indicated common TCI state ID to provide QCL Type-D indication and to determine UL TX spatial filter. The determined CC-specific ~~QCL-TypeD~~ RSs for the set of configured CCs are further associated with a same QCL-TypeD RS.   + Note: From a previous agreement, the common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs   + FFS: how to provide the CC-specific RSs in a TCI sate of the single RRC TCI state pool shared among the set of configured CCs, e.g., the BWP/CC ID for the source RS for QCL Type-D reference and/or UL TX spatial reference can be absent in a TCI state * ~~A single RRC pool of TCI states is used for the set of CCs~~ |
| vivo | We are basically fine with the direction of compromise. The following update is suggested:  Offline FL proposal 1: On Rel.17 unified TCI framework, for QCL-Type D configuration in TCI state(s) shared across a set of CC/BWPs (that is associated with the same gNB beam)   * CC/BWP-specific QCL-TypeD RS can be determined from the indicated common TCI state ID. The determined QCL-TypeD RSs for the set of CC/BWPs are further associated with a same QCL-TypeD RS.   + Note: From a previous agreement, the common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs * A single RRC pool of TCI states is used for the set of CC/BWPs |
| Mod V18 | The formulation from MTK looks good – the proposal is revised below (also including vivo’s comment).  Also note that “TCI state(s) shared across a set of CCs” is not used anymore – cf. offline comments from Huawei |
| **Offline FL proposal 1**: On Rel.17 unified TCI framework, ~~for QCL-Type D configuration in TCI state(s) shared across a set of CCs (that is associated with the same gNB beam)~~ a single RRC pool of TCI states is used for common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs/BWPs   * A CC/BWP-specific ~~QCL-TypeD~~ source RS can be determined from the indicated common TCI state ID to provide QCL Type-D indication and to determine UL TX spatial filter. The determined ~~QCL-TypeD~~ CC-specific source RSs for the set of configured CCs/BWPs are further associated with a same QCL-TypeD RS.   + Note: From a previous agreement, the common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs/BWPs   + FFS: how to provide the CC/BWP-specific RSs in a TCI sate of the single RRC TCI state pool shared among the set of configured CCs/BWPs, e.g., the BWP/CC ID for the source RS for QCL Type-D reference and/or UL TX spatial reference can be absent in a TCI state * ~~A single RRC pool of TCI states is used for the set of CCs~~ | |
| Apple | It seems we need some definition of “the set of configured CCs/BWPs”. I suggest we add a sub-bullet to clarify it, but I am not sure whether it is the common understanding.  In addition, I do not fully understand the intention to change “CC-specific” into “CC/BWP-specific”, it seems all the CSI-RS resources are configured in CC level instead of BWP level.  **Offline FL proposal 1**: On Rel.17 unified TCI framework, ~~for QCL-Type D configuration in TCI state(s) shared across a set of CCs (that is associated with the same gNB beam)~~ a single RRC pool of TCI states is used for common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs/BWPs   * A CC/BWP-specific ~~QCL-TypeD~~ source RS can be determined from the indicated common TCI state ID to provide QCL Type-D indication and to determine UL TX spatial filter. The determined ~~QCL-TypeD~~ CC-specific source RSs for the set of configured CCs/BWPs are further associated with a same QCL-TypeD RS.   + Note: From a previous agreement, the common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs/BWPs   + FFS: how to provide the CC/BWP-specific RSs in a TCI sate of the single RRC TCI state pool shared among the set of configured CCs/BWPs, e.g., the BWP/CC ID for the source RS for QCL Type-D reference and/or UL TX spatial reference can be absent in a TCI state * “a set of configured CCs/BWPs” at least includes the CCs/BWPs in one band * ~~A single RRC pool of TCI states is used for the set of CCs~~ |
| SS3 | We are fine with the direction of proposal 1 from the moderator. But we would like to understand the motivation of changing “CC-specific” to “CC/BWP-specific”. It seems sufficient to have the source-RS configured at the CC-level rather than at the BWP-level. Anyway, within a CC there can only be one active BWP at a time. |
| LG | For a single RRC pool of TCI state across CCs, the concern is mainly on how to select N TCI states for activation by MAC CE **based on the assumption that QCL-TypeA RS is per CC**. Then, it is difficult to handle the selection since desired pairs of TypeA and TypeD source would be different per CC, which leads a joint selection on a cell group manner. Also, the issue is dependent on the results of UL specific parameters (PC, PL RS, TA etc.). Most of all, while the reduction of RRC payload with a single RRC pool is valid, the main portion of overall payload is from the RS configurations per CC. On the contrary, TCI state pool configuration requires much less payload compared to CSI-RS configuration, measurement/reporting configuration etc. So, we think that separate RRC pool per CC is cleaner, same as legacy.  [Mod: Re the difficulty of handling selection of CC-specific Type-A and D RSs (where a same TypeD RS is ultimately used) using a single TCI state pool, this may be a subjective assessment that depends on gNB implementation.  Given that some Alt2 companies can compromise only with the common pool (and this is supported by some other), from FL perspective I believe this is a fair compromise from both sides.] |
| MediaTek | Re vivo’s comment, if our understanding is correct, “a set of configured CCs/BWPs” means “all BWPs in a set of configured CCs”. If so, it would be better to clarify it in the proposal to avoid confusion. For “CC/BWP-specific”, we think CC-specific may be sufficient. On potential issue from “BWP-specific” is that how to handle the case if the “BWP-specific” CSI-RS is not configured in the active BWP since CSI-RS resource is configured in BWP level (BWP ID is provided in each resource setting).  Re Apple’s comment, we share the same understanding since only intra-band CA is agreed in previous meeting but inter-band CA is still FFS.    **Agreement**  On Rel-17 unified TCI framework, support common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs:   * The above applies to intra-band CA * The above applies to joint DL/UL and separate DL/UL beam indications * Just as Rel.16, the RS in the TCI state that provides QCL-TypeA [or QCL-TypeB] shall be in the same CC as the target channel or RS * The common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs * FFS: The above also applies to inter-band CA * … |
| CATT | 1. We support the moderator’s proposal on agreeing on Alt-1. 2. On the number of TCI pool (joint pool vs. per-CC pool), we prefer to not rush into a conclusion. Given there are other undecided issues (e.g. power control as raised by LG) it may require further studies. So a slightly reworded change is below.   **Offline FL proposal 1**: On Rel.17 unified TCI framework, ~~for QCL-Type D configuration in TCI state(s) shared across a set of CCs (that is associated with the same gNB beam) a single RRC pool of TCI states is used~~ for common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs/BWPs   * A CC/BWP-specific ~~QCL-TypeD~~ source RS can be determined from the indicated common TCI state ID to provide QCL Type-D indication and to determine UL TX spatial filter. The determined ~~QCL-TypeD~~ CC-specific source RSs for the set of configured CCs/BWPs are further associated with a same QCL-TypeD RS.   + Note: From a previous agreement, the common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs/BWPs   + FFS: how to provide the CC/BWP-specific RSs in a TCI sate of the single RRC TCI state pool shared among the set of configured CCs/BWPs, e.g., the BWP/CC ID for the source RS for QCL Type-D reference and/or UL TX spatial reference can be absent in a TCI state * ~~A single RRC pool of TCI states is used for the set of CCs~~   [Mod: Please check my comment for LG and the preceding discussion. Alt1 + common pool is a compromise proposal. Given that the # Alt1 proponents is not overwhelmingly larger than Alt2, from FL perspective, this is a good way to move forward for this sticky issue (discussed since 11/2020) ☹] ] |
| Docomo | Re vivo’s comment, if we refer Rel.15/16 principle, TCI state or QCL source RS is configured per BWP in a CC, but “CC list” is defined per CC. We believe, the “CC list” should be “CC list”, not “BWP/CC list”. Thus, we prefer to update as “a set of configured CCs~~/BWPs~~”.  The next question is whether QCL source RS is configured per BWP or per CC. Since “the user” of unified TCI state will be RRC parameters configured per BWP (e.g. PDCCH-Config, PDSCH-Config, etc.), we think per BWP is safer. If QCL source RS is configured per CC, we may need to handle the case if QCL source RS is outside of active BWP. So, we can keep BWP in “A CC/BWP-specific source RSs”,  Note: Rel.15/16 principle:   * Rel.15/16 TCI state is configured per BWP in a CC. QCL source RS is configured per BWP in a CC. * Rel.16 simultaneous beam update list is indicated in CC-level. The same set of TCI state IDs are applied for all BWP in the indicated CCs. |
| Mod V25 | Added a sub-bullet to clarify “configured CCs/BWPs” per inputs from Apple and MTK – which should address the first concern from NTT Docomo. Also removed “BWP-specific” since it seems controversial.  @vivo: Could you please check?  Re removing “a single RRC pool”, for now I am keeping this since this is an outcome of a compromise (please see the above discussion) which I think is reasonable. |
| **Offline FL proposal 1**: On Rel.17 unified TCI framework,a single RRC pool of TCI states is used for common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs/BWPs   * A CC~~/BWP-specific~~ source RS can be determined from the indicated common TCI state ID to provide QCL Type-D indication and to determine UL TX spatial filter. The determined CC-specific source RSs for the set of configured CCs/BWPs are further associated with a same QCL-TypeD RS.   + Note: From a previous agreement, the common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs/BWPs   + FFS: how to provide the CC/BWP-specific RSs in a TCI state of the single RRC TCI state pool shared among the set of configured CCs/BWPs, e.g., the BWP/CC ID for the source RS for QCL Type-D reference and/or UL TX spatial reference can be absent in a TCI state * “A set of configured CCs/BWPs” includes all the BWPs in the set of configured CCs in one band | |
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### How unified TCI is applied to other signals/channels

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| 1.4 | Whether Rel-17 DL and, if applicable, joint TCI also applies to the following signals.   * If not applicable, how to provide DL QCL information for those signals   Note: UE-dedicated reception on PDSCH and all/subset of CORESETs have been agreed | CSI-RS resource for CSI:   * **Yes (21)**: Lenovo/MoM, Ericsson, Nokia/NSB, OPPO, Spreadtrum, MTK, APT/FGI, Intel, Convida, AT&T, Samsung, Apple (at least for default AP-CSI-RS beam), Sony, Qualcomm, Xiaomi, NTT Docomo, Intel, CATT * **No (3)**: Huawei, HiSi, Futurewei (need further discussion)   Some CSI-RS resource(s) for BM (if so, which one(s), e.g. aperiodic, repetition ‘ON’)   * **Yes (16)**: Ericsson, Nokia/NSB, OPPO, MTK, APT/FGI, Intel, AT&T, Samsung, Apple (at least for default AP-CSI-RS beam), Sony (at least for repetition ‘ON’), Qualcomm, Xiaomi, NTT Docomo, Intel * **No (5)**: Huawei, HiSi, Futurewei (need further discussion, depending on whether the resource is repeated or not), Spreadtrum, vivo   CSI-RS for tracking:   * **Yes (10)**: Lenovo/MoM, Ericsson, Spreadtrum, AT&T, Nokia/NSB, Sony, Qualcomm, CATT * **No (5)**: Huawei, HiSi, MTK, Futurewei, NTT Docomo |
| 1.5 | Whether Rel-17 UL and, if applicable, joint TCI also applies to the following signals.   * If not applicable, how to provide UL TX spatial reference information for those signals | Some SRS resources or resource sets for BM:   * **Yes (14)**: Lenovo/MoM, Ericsson, OPPO, MTK, Intel, APT/FGI, Nokia/NSB, Sony, Qualcomm, Xiaomi, Convida * **No (4)**: Huawei, HiSi, Futurewei (need further discussion) , Spreadtrum (reuse R15 TCI framework) |
| 1.12 | TCI for non-UE-dedicated reception on PDSCH and all/subset of CORESETs  Alt1: Extend (use) Rel-17 unified TCI  Alt2: Reuse Rel-15/16 TCI | **Alt1**: vivo, Samsung, Qualcomm, Futurewei, , Ericsson  **Alt2**: Apple (modify Alt2 as “reuse Rel-15/16 QCL assumption”, since many cases are for idle mode UE and there is no TCI), Huawei, HiSi |

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| The following questions are pertinent to sub-issues 1.4, 1.5, and 1.12:   * QA. Does Rel-17 unified TCI apply to a channel, a CORESET, or a signal *other tha*n the ones already agreed.   + For DL: CSI-RS resource for CSI, some CSI-RS resource(s) for BM, CSI-RS for tracking, non-UE-dedicated reception on PDSCH and all/subset of CORESETs   + For UL: Some SRS resources or resource sets for BM * QB. If the answer to QA is yes for any of those channels/signals, how does this apply? * QC. If the answer to QA is no for any of those channels/signals, how does the system provide DL QCL or UL TX spatial reference information to the channel/signal?   In regard to QB, it was pointed out (by Claes) that two possible interpretations exist. We use CSI-RS resource for CSI as an example to illustrate the point.   * Interpretation 1: The CSI-RS resource for CSI shares the same (Rel-17 DL or, if applicable, joint) TCI state machine (hence ‘DL RX beam tracking loop’) as that for UE-dedicated reception on PDSCH and all/subset of CORESETs. This works regardless of the values of M and/or N.   + In this case, the Rel-17 DL or, if applicable, joint TCI state used for the CSI-RS resource for CSI needs to be associated with some UE-dedicated reception on PDSCH and all/subset of CORESETs. * Interpretation 2: The CSI-RS resource for CSI uses a different (Rel-17 DL or, if applicable, joint) TCI state machine (hence ‘DL RX beam tracking loop’) as that for UE-dedicated reception on PDSCH and all/subset of CORESETs. This requires M>1 and/or N>1.   + In this case, a separate Rel-17 DL or, if applicable, joint TCI state dedicated to the CSI-RS resource for CSI can be used without any association with any UE-dedicated reception on PDSCH and all/subset of CORESETs. |

Table 2 Companies’ inputs: unified TCI applied on other signals/channels

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| **~~Please share your view on the following questions~~**   * **~~Q1. Regardless your views on 1.4/1.5/1.12, which interpretation do you hold?~~**   **See the modified question after Mod V5 comment** | |
| **Company** | **Input** |
| MediaTek | On QA: Our understanding on “applying Rel-17 unified TCI” is always Interpretation 1, and we are okay to support Rel-17 unified TCI “optionally” apply to at least CSI-RS resource for CSI, i.e., it shares the same TCI state machine as that for UE-dedicated reception on PDSCH and all/subset of CORESETs.  On QB: Interpretation 1  On QC: For those signals and non-UE-dedicated channels not applying Rel-17 unified TCI, separate “TCI state machines” are needed, and legacy Rel-15/16 signaling mediums are used for them (no new signaling mechanism). However, these “TCI state machines” still can share the same TCI state pool used for Rel-17 unified TCI (not sure whether this is Interpretation 2). |
| OPPO | QA: For DL, yes to CSI-RS for CSI and one set of CSI-RS set with repetition = ‘ON’, For UL: Yes to one SRS resource set for BM.  QB: Interpretation 1.  QC: For the channels/signals with No in QA, the scheme specified in rel-15/16 is applied. |
| Ericsson | QA: Our understanding is that “applying Rel-17 unified TCI” is Interpretation 2. Hence “unified TCI” means unified across UL and DL. “Common beam operation” is a very important special case of unified TCI.  QB: Interpretation 2. We understand how this would imply M>1 and N>1. Rel-15/16 signalling/configuration mechanisms would be reused when needed, but would indicate a R17 TCI state.  On the common beam operation: In Rel-15, aperiodic CSI-RS for CSI can use a default beam when the triggering offset of the CSI-RS is smaller than the UE capability. The same rule was introduced for aperiodic CSI-RS for BM in Rel-16. Reporting using a default beam is very useful in practice, and reduces the number of aperiodic triggering states. We propose that such common beam operation is supported also for R17 TCI states. |
| Samsung | QA: CSI-RS for CSI should perform measurements on a CSI-RS resource with the same beam as that of the corresponding PDCCH/PDSCH. Same common beam as that used for PDCCH/PDSCH.  CSI-RS for beam management with repetition on, should have the same beam as that of the corresponding PDCCH/PDSCH for Rx beam refinement. Same common beam as that used for PDCCH/PDSCH.  CSI-RS for tracking can itself be a source RS for PDCCH/PDSCH, using a common beam would create a circular relation and hence should be avoided.  QB: Interpretation 1.  QC: If a channel is not part of a common beam used for PDCCH/PDSCH, its beam is signalled separately, we are open to consider the following options:   * Signalling based Rel-17 TCI states. * Signalling based on Rel-15/16 TCI states, this might increase the configuration overhead, as the UE would need to be configured with the Rel-15/16 TCI states and Rel-17 TCI states. |
| Mod V5 | For brevity, I will use the term **‘other signals/channels’** to refer to those mentioned in QA below   * *QA. Does Rel-17 unified TCI apply to a channel, a CORESET, or a signal other than the ones already agreed.*    + *For DL: CSI-RS resource for CSI, some CSI-RS resource(s) for BM, CSI-RS for tracking, non-UE-dedicated reception on PDSCH and all/subset of CORESETs*   + *For UL: Some SRS resources or resource sets for BM*   From the above comments, I observe the following additional points:   * [MTK, Ericsson] It should be possible to use Rel-17 TCI states for all ‘other signals/channels’. The question, for a given ‘other signal/channel’, is whether Interpretation 1 or Interpretation 2 is possible for the signal/channel of interest. * [MTK, Ericsson] Corollary: with Interpretation 2, the ‘other signal/channel’ of interest will use a TCI state update signaling/configuration mechanism different from that used for PDSCH/UE-dedicated CORESET/PUSCH/PUCCH. That signaling mechanism could be a separate Rel-17 MAC CE/DCI based (e.g. M/N>1), or even Rel-15/16 (TBD). But this ‘other signal/channel’ still uses Rel-17 TCI states.   So we can reorient the discussion assuming only Rel-17 TCI states are used for all the ‘other signals/channels. The question can be reframed below. |
| **Please share your view on the following questions**  **Given that all the ‘other signals/channels’ (listed in QA above) configured with Rel-17 unified TCI states, for each of those ‘other signals/channels’**   * **Q1. Which ones of the ‘other signals/channels’ should be able to share the same Rel-17 “TCI state machine” as PDSCH/UE-dedicated CORESETs/PUSCH/PUCCH (i.e. Interpretation 1)?** * **Q2. For the ‘other signals/channels’ that do not admit Interpretation 1 (therefore, admit only Interpretation 2), what TCI state update signaling/configuration mechanism(s) should be used?** | |
| OPPO | Q1: CSI-RS for CSI, one CSI-RS resource set with repetition = ‘On’ and one SRS resource set for BM  Q2: the rel15/re16 TCI update signaling/configuration mechanism shall be used. |
| MediaTek | Q1: “Optionally” apply to at least CSI-RS for CSI. In Rel-15/16, the common beam operation is only valid for AP CSI. We see it is also beneficial to allow such common beam operation for P and SP CSI-RS.  Q2: By assuming only Rel-17 TCI states are used, Rel-15/16 signaling/configuration mechanism for TCI/spatial relation should be used. |
| Apple | Q1: At least aperiodic CSI-RS for CSI and BM, which is to avoid default beam issue – potential default beam mismatch between A-CSI-RS and PDSCH. In addition, AP-TRS can also be considered, then the AP-TRS can be triggered with a small scheduling offset. But if all types of AP-CSI-RS are included, it is better to revise the agreement a little bit to include TRS only as the source RS.  We are also open to extend unified TCI for P/SP-CSI-RS with separate signaling (legacy RRC/MAC CE by using unified TCI), so that UE does not need to maintain two TCI states pools: R17 TCI and R16 TCI.  Q2: It seems there will be no other signals/channels. |
| Huawei, HiSilicon | The term of “TCI state machine” is confusing to us. In R15/R16, there is a TCI state pool configured under PDSCH config, where PDCCH and CSI-RS can be configured/assigned/indicated with a TCI state from this TCI state pool. In UE feature discussion, when defining active TCI states for PDCCH/PDSCH, the TCI states configured for CSI-RS is not considered. The “TCI state machine” here seems to refer to the pool of active TCI states for PDCCH/PDSCH in R15/R16, and we failed to understand why the configured/indicated TCI states for CSI-RS should follow that for PDCCH/PDSCH.  For example, there can be up to 192 CSI-RS resources for BM, CSI, and tracking purposes, it is unclear which of them should follow the active beam pair for PDCCH/PDSCH transmission, and how the gNB would know if whether to apply is optionally configured by RRC in advance, especially for periodic CSI-RS and when UE is moving around. We are not sure whether the underlying assumption here is that gNB can change the Tx beam of periodic CSI-RS when UE moves around. If that is the case, we suggest explicitly listing it out for consideration.  In addition, in a typical QCL chain that comes with explicit TCI indication, it is PDCCH/PDSCH to follow CSI-RS, not the other way around. Similar to Ericsson, we are supportive to inherit the R15/R16 mechanism that aperiodic CSI-RS can use a default QCL (following lowest CORESET) when the triggering offset is smaller than the UE capability. We believe this is an implied behavior, once the joint or DL TCI in R17 is applied to PDCCH reception, and no further agreement is needed.  So far, R17 TCI is mainly for data/control channels, which is aligned with the WID (focusing on data/control channels), and we haven’t agreed that R17 TCI will be extended and applied to all other channel/signal(s). If the proposal here is that R17 TCI will essentially replace R16 TCI and spatial relation and then be applied everywhere, it is better to spell it out so that we can assess the impacts to the system and discuss whether to do it this way. |
| Sony | Q1: CSI-RS for CSI, CSI-RS for tracking, and CSI-RS for BM with repetition ON. In Rel.15/16 QCL rules, various types of CSI-RS can leverage TCI states for UE to retune Rx beam for its DL reception on CSI-RS. In Rel.17, if we stick to only DL channels, rather than DL signals, then UE may have to maintain two parallel TCI state pools, one for Rel.15/16 and the other one for Rel.17.  Q2: If any, what we have is only to reuse Rel.15/16 signaling mechanism(s) on TCI states. |
| ZTE | Q1: Aperiodic CSI-RS for CSI and aperiodic CSI-RS for BM.   * Besides, it is noted that periodic and semi-persistent CSI-RS for CSI, for BM and periodic TRS should be precluded in our views. Periodic DL RS are usually cell-specific for saving RS overhead, and dynamically updating the TCI state of the RS means that we have to provide UE-specific periodic RS with huge RS overhead from gNB perspective.   Q2: Then, we share the same views with OPPO, MTK and Sony that Rel-15/16 TCI configuration mechanism should be reused accordingly. |
| Mod V15 | From the above comments, we should be able to use the ‘offline FL proposal 2.1, 2.2, and 2.3’ below as a starting point to resolve this issue.  **Please share your comments on the 3 proposals below, if any. I will include the final forms (from this offline discussion) in my round 0 FL summary.** |
| **Offline FL proposal 2.1**: On Rel.17 unified TCI framework,   * Any DL RS or DL physical channel can be configured as a target signal/channel of a Rel-17 DL, or if applicable, joint TCI (hence the Rel-17 DL, or if applicable, joint TCI state pool) * Any UL RS or UL physical channel can be configured as a target signal/channel of a Rel-17 UL, or if applicable, joint TCI (hence the Rel-17 UL, or if applicable, joint TCI state pool)   **Offline FL proposal 2.2**: On Rel.17 unified TCI framework, in RAN1#105-e, discuss and decide   * Whether each of the following DL RSs and channels can share the same Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC   + CSI-RS resources for CSI   + Some CSI-RS resources for BM, if so, which ones (e.g. aperiodic, repetition ‘ON’)   + CSI-RS for tracking   + Non-UE-dedicated reception on PDSCH and all/subset of CORESETs * Whether each of the following UL RSs and channels can share the same Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC   + Some SRS resources or resource sets for BM   **Offline FL proposal 2.3**: On Rel.17 unified TCI framework, Rel-15/16 TCI state update signaling/configuration mechanism(s) are reused to update the Rel-17 TCI state for the following signal/physical channel:   * Any DL RS or DL physical channel that does not share the same Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC * Any UL RS or UL physical channel that does not share the same Rel-17 TCI state dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC | |
| vivo | Not sure of the intention of FL proposal 2.1.  [Mod: Please check the comment from Huawei: “If the proposal here is that R17 TCI will essentially replace R16 TCI and spatial relation and then be applied everywhere, it is better to spell it out so that we can assess the impacts to the system and discuss whether to do it this way”.  Mod: This is to avoid mixing Rel-15/16 and Rel-17 TCI states in one deployment which will complicate NW and UE implementation as pointed out by a number of companies – see above.  But this does not mean that all signals/channels will share the SAME Rel-17 TCI state. Proposals 2.2/2.3 go into further details on this issue. That is, ‘other’ signals/channels can use Rel-17 TCI states from the SAME POOL as UE-dedicated PDSCH/CORESET or for UL PUSCH/PUCCH, but they may be configured with DIFFERENT Rel-17 TCI states.]  For proposal 2.2, we would like to point out that for non-UE-dedicated reception on PDSCH and all/subset of CORESETs, there is also an interpretation-2: the extension of Rel-17 framework for these channels would be applied only for the case with M>1, N>1 when DCI based beam indication is used. For the case M=1, N=1, the application of the indicated beam to non-UE-dedicated reception on PDSCH and all/subset of CORESETs is in-appropriate.  [Mod: Using M/N>1 is not within the scope of proposal 2.2 since using M/N>1 implies that the resulting Rel-17 TCI state will be different from UE-dedicated PDSCH/CORESET or for UL PUSCH/PUCCH, but they may be configured with DIFFERENT Rel-17 TCI states.  Mod: In fact, using M/N>1 for this purpose is an alternative to reusing Rel-15/17 signaling/configuration mechanism proposed in proposal 2.3]  For proposal 2.3, there is still ongoing discussion regarding whether MAC CE can be used to update TCI state for the CSI-RS resources. Conclusion like 2.3 may not be necessary at this stage.  [Mod: In this case we can list two alternatives for proposal 2.3] |
| Mod V18 | Revised proposal 2.3 to accommodate vivo’s comments |
| **Offline FL proposal 2.1**: On Rel.17 unified TCI framework,   * Any DL RS or DL physical channel can be configured as a target signal/channel of a Rel-17 DL, or if applicable, joint TCI (hence the Rel-17 DL, or if applicable, joint TCI state pool) * Any UL RS or UL physical channel can be configured as a target signal/channel of a Rel-17 UL, or if applicable, joint TCI (hence the Rel-17 UL, or if applicable, joint TCI state pool)   **Offline FL proposal 2.2**: On Rel.17 unified TCI framework, in RAN1#105-e, discuss and decide   * Whether each of the following DL RSs and channels can share the same Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC   + CSI-RS resources for CSI   + Some CSI-RS resources for BM, if so, which ones (e.g. aperiodic, repetition ‘ON’)   + CSI-RS for tracking   + Non-UE-dedicated reception on PDSCH and all/subset of CORESETs * Whether each of the following UL RSs and channels can share the same Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC   + Some SRS resources or resource sets for BM   **Offline FL proposal 2.3**: On Rel.17 unified TCI framework, ~~Rel-15/16 TCI state update signaling/configuration mechanism(s) are reused to update the Rel-17 TCI state~~ for the following (‘other’) signal/physical channel:   * Any DL RS or DL physical channel that does not share the same Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC * Any UL RS or UL physical channel that does not share the same Rel-17 TCI state dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC   Discuss and down-select in RAN1#105-e between the following two alternatives:   * Alt1. Rel-15/16 TCI state update signaling/configuration mechanism(s) are reused to update/configure the Rel-17 TCI state * Alt2. New TCI state update signaling/configuration mechanism(s) are used, e.g. using M>1 and/or N>1 with Rel-17 MAC-CE/DCI-based beam indication for Rel-17 joint/separate TCI | |
| LG | FL proposal 2.1: Ok in principle, but need to clarify ‘any DL/UL RS/channel’ are the agreed ones. Details of this configuration needs to be discussed later, e.g. configuring per RS/channel resource set.  [Mod: The intention is for signals/channels that are valid targets in Rel-15/16. Now clarified]  FL proposal 2.2 & 2.3: Ok |
| MediaTek | For proposal 2.3, we would like to clarify whether “Rel-15/16 TCI state update signaling/configuration mechanism(s)”in this proposal also includes Rel-15/16 spatial relation update for UL. If not, for ‘other’ signal/physical channel configured with spatial relation info, Rel-17 TCI doesn't have to be configured for them. And we are okay to it since spatial relation info doesn't need an RRC pool. |
| CATT | Proposal 2.1: Support.  Proposal 2.2: Support  Proposal 2.3: Support. |
| Mod V25 | Updated proposals based on LG’s and MTK’s comments |
| **Offline FL proposal 2.1**: On Rel.17 unified TCI framework,   * Any DL RS or DL physical channel that is a valid target signal/channel within the Rel-15/16 QCL rules can be configured as a target signal/channel of a Rel-17 DL, or if applicable, joint TCI (hence the Rel-17 DL, or if applicable, joint TCI state pool) * Any UL RS or UL physical channel that is a valid target signal/channel within the Rel-15/16 UL spatial relation rules can be configured as a target signal/channel of a Rel-17 UL, or if applicable, joint TCI (hence the Rel-17 UL, or if applicable, joint TCI state pool)   **Offline FL proposal 2.2**: On Rel.17 unified TCI framework, in RAN1#105-e, discuss and decide   * Whether each of the following DL RSs and channels can share the same Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC   + CSI-RS resources for CSI   + Some CSI-RS resources for BM, if so, which ones (e.g. aperiodic, repetition ‘ON’)   + CSI-RS for tracking   + Non-UE-dedicated reception on PDSCH and all/subset of CORESETs * Whether each of the following UL RSs and channels can share the same Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC   + Some SRS resources or resource sets for BM   **Offline FL proposal 2.3**: On Rel.17 unified TCI framework, for the following (‘other’) signal/physical channel:   * Any DL RS or DL physical channel that does not share the same Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC * Any UL RS or UL physical channel that does not share the same Rel-17 TCI state dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC,   Discuss and down-select in RAN1#105-e between the following two alternatives:   * Alt1. Rel-15/16 TCI state and, if applicable, UL spatial relation update signaling/configuration mechanism(s) are reused to update/configure the Rel-17 TCI state * Alt2. New TCI state update signaling/configuration mechanism(s) are used, e.g. using M>1 and/or N>1 with Rel-17 MAC-CE/DCI-based beam indication for Rel-17 joint/separate TCI | |
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