**3GPP TSG RAN WG1 Meeting #102-e R1-200xxxx**

**E-meeting, August 17-28, 2020**

**Agenda Item: 5**

**Source: Moderator (Huawei)**

**Title: Email discussion on CSI-RS only beam correspondence**

**Document for: Discussion**

# Introduction

In [1], RAN4 asked RAN1 several questions on using CSI-RS without QCL indication for beam management purposes. This summary is to collect views from companies and facilitate a reply LS to RAN4.

# Views from companies

This section summarizes companies’ views on questions from RAN4.

***Question 1:*** Does RAN1 consider it valid scenario(s) that P1 CSI-RS has no QCL relation for Rel-16? If valid, what are the corresponding usage scenarios? Has RAN1 analysed impact on UE mobility, scheduling restriction and overhead, UE power consumption, etc., with respect to number of active TCI states?

***Views:***

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| Huawei, HiSilicon | In our view, using P1 CSI-RS without QCL indication is valid starting from Rel-15. Based on previous RAN1 agreements and current RAN2 specifications (listed in [R1-2006939](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006939.zip)), it is clear that CSI-RS reception without beam-related indication is supported, CSI-RS based P1 procedure is supported, by default CSI-RS may be not QCLed to an SSB, and QCL indication for periodic CSI-RS is strictly optional. As for usage scenarios, P1 CSI-RS without QCL indication can be used for beam measurement targeting at lower latency and for multi-TRP transmission where CSI-RS may come from a TRP which is not sending SSB. To our knowledge, RAN1 did not discuss much about the impacts on UE mobility, scheduling restriction and overhead, UE power consumption, with respect to number of active TCI states, but indeed introduced UE capability reporting on number of active TCI states (e.g., UE feature 2-4 in 38.822 for Rel-15, UE feature 16-2a-7 in R1-2004970 for Rel-16). |
| Apple | In our view, there is no usage scenario for CSI-RS without QCL relation. RAN1 has not defined any UE behaviour for CSI-RS without QCL relation.  RAN1 has not analysed much about the impact on UE mobility, scheduling restriction and overhead, UE power consumption with respect to number of active TCI states. |
| FUTUREWEI | First, based on the LS text, the QCL relation in this question is only about QCL-TypeD. Let us know if this is not the correct understanding. For QCL-TypeD, our understanding is that this scenario is valid from Rel-15 and hence also still valid in Rel-16. The scenarios may include the case where a TRP is not configured with SSB. Other cases are not excluded and up to gNB implementation. The impact on mobility, scheduling restriction and overhead, power consumption were not specifically analysis in RAN1 before, not just for this case but generally not for most of the BM cases. |
| vivo | We have got one question and one comment:   1. Regarding the QCL, is it specifically referring to QCL-D? Or it also includes other QCL? 2. There are similar discussion in Rel-16 multi-TRP on whether it is valid operation for UE to track a signal/channel (other than SSB) without QCL source. There is no common understanding regarding this issue. The results of the discussion is that Rel-17 further enhance the TCI state with inter-cell QCL source. Similarly, for RAN4 Rel-16 discussion, it may also be very challenging to conclude that UE is able to receive a signal without QCL source. |
| LG | We share similar understanding with Huawei and FUTUREWEI that CSI-RS without QCL indication has been supported from Rel-15. With this, it is allowed to perform BM across multiple TRPs. QCL is an assist information for UE. If QCL-D is absent, UE may use un-optimized Rx beam to measure RSRP/SINR for the CSI-RS but it is also up to gNB’s choice whether/how to use the reported value from the un-optimized Rx beam to our understanding. If repetition is OFF, typical UE implementation would use a same Rx beam across multiple CSI-RS resources in a set so it may not an issue if some of CSI-RS resources has no QCL-D info. |
| ZTE | We share the same views with Huawei that P1 CSI-RS without QCL indication is valid starting from Rel-15. Regarding vivo’s comments, we think that the CSI-RS can be configured with QCL-TypeA/B/C only if required, and meanwhile “QCL configured as none” is also supported in Rel-15. |
| Samsung | We have the same understanding with Huawei and LG. P1 CSI-RS with no QCL relation is valid for multi-TRP and inter-cell cooperation scenario where P1 CSI-RS is from the TRP/cell other than the camped-on one.  RAN1 hasn’t analysed impact on mobility, scheduling restriction, overhead, and power consumption regarding this case. |
| MediaTek | For BM, CSI-RS without QCL indication is useful and allowed, either in Rel-15 or in Rel-16, which can be used as SSB for initial beam acquisition. RAN1 didn't further discuss related UE impact. |
| CATT | Share similar views with Huawei/Futurewei/ZTE/Samsung that P1-CSI-RS without QCL indication is valid from Rel.15. Configuration of QCL source is optional and up to network. RAN1 hasn’t analysed impact on mobility, scheduling restriction, overhead, and power consumption regarding this case. |
| InterDigital | Share similar views with Huawei/Futurewei/ZTE/Samsung/CATT that P1-CSI-RS without QCL indication is valid from Rel.15 and RAN1 hasn’t analysed impact on mobility, scheduling restriction, overhead, and power consumption regarding this case. |
| Intel | 1. It should be clarified that “no QCL relation” in the LS means “no QCL Type D relation”  2. We think that it is possible configuration from specification perspective. However, support of such configuration in the practical network may be problematic, since CSI-RS should still have SSB as source for some QCL parameters (average delay and Doppler shift) to acquire initial time and frequency sync. In this case that SSB may not be a good reference for CSI-RS, since it may be transmitted from other TRP/beam. RAN1 has not analysed the impact of such configuration on the performance. |
| OPPO | We assume the QCL relation mainly means the QCL TypeD.  CSI-RS without QCL configuration is a valid case from the perspective of specification. The usage scenario is for P1 beam alignment. If no QCL is configured to CSI-RS, it is up to UE implementation on how to receive the CSI-RS. RAN1 did not analyse the impact on UE mobility, scheduling restriction and overhead, UE power consumption with respect to that. |
| Nokia, NSB | CSI-RS without QCL configuration is a valid Rel-15 configuration. As with a vast number of other configurations, RAN1 did not investigate impact on mobility, scheduling or UE power consumption. |
| Qualcomm | We believe there is no valid use case at least for single TRP with BWP having no SSB. In this case, no point for UE to run 2 sets of beam tracking loops for SSB and CSI-RS. For mTRP with TRP not sending SSB, that TRP cannot be used for initial access, and motivation for it is unclear. For inter-cell beam indication, it is not discussed in R16 BM. |

***Summary on August 19:***

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| Moderator: By ‘QCL relation’, RAN4 meant to say TypeD QCL. This is listed in Table 1 of the RAN4 LS and also confirmed by the contact person.  ***Question 1-1:*** Does RAN1 consider it valid scenario(s) that P1 CSI-RS has no QCL relation for Rel-16?  Yes (12 companies): Huawei, HiSilicon, FutureWei, LG, ZTE, Samsung, MediaTek, CATT, InterDigital, Intel (SSB may not be a good reference for CSI-RS), OPPO, Nokia, NSB  No: Apple (1 companies)  Other: vivo (challenging to conclude)  ***Question 1-2:*** If valid, what are the corresponding usage scenarios?  P1 beam alignment similar as SSB (4 companies): Huawei, HiSilicon, MediaTek, OPPO  Multi-TRP with TRP not sending SSB (5 companies): Huawei, HiSilicon, FutureWei, LG, Samsung  Inter-cell cooperation (1 company): Samsung  No usage scenario (1 company): Apple  ***Question 1-3:*** Has RAN1 analysed impact on UE mobility, scheduling restriction and overhead, UE power consumption, etc., with respect to number of active TCI states?  No, similar as a vast number of other configurations (12 companies): Huawei, HiSilicon, Apple, FutureWei, Samsung, MediaTek, CATT, InterDigital, Intel, OPPO, Nokia, NSB |

***Question 2:*** Whether there is UE behaviour definition/expectation when P1 CSI-RS QCL relation is configured as ‘none’ and to SSB? For example: are resource prioritization rules or default QCL assumption rules when overlapped with other resources (e.g. PDCCH, DMRS) established for both scenarios?

***Views:***

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| Huawei, HiSilicon | Based on previous agreements (as listed in [R1-2006939](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006939.zip)), in our understanding, for P1 CSI-RS without QCL indication, and for SSB without QCL indication, UE is expected to try different Rx beams without assuming that gNB is transmitting with the same Tx beam (which is the definition of P1 procedure). |
| Apple | No |
| FUTUREWEI | Agree with Huawei’s understanding |
| vivo | We would like to understand the question better:   1. What does it mean by “QCL configured as ‘none’ and to SSB”? Are these two cases, one without QCL, one with QCL to SSB? 2. For cases when the QCL sources is not configured, our understanding is that there is no behaviour established in RAN1 related to resource prioritization rules or default QCL assumption rules when overlapped with other resources (e.g. PDCCH, DMRS). |
| LG | No, i.e. it is up to UE how to measure the RS with no QCL information |
| ZTE | The UE behaviour is similar to SSB within SMTC. |
| Samsung | RAN1 specified UE behaviour expection for CORESET0 such that, the QCL-TypeD reference of CORESET0 should be a CSI-RS QCL’ed with an SS/PBCH block. For CORESETs other than CORESET0, there is no such restriction so far which implies that UE can expect a CSI-RS QCL’ed with ‘none’ to be configured as a QCL-TypeD reference for those CORESETs. |
| MediaTek | RAN1 has specified that for CSI-RS for BM with *repetition* set to 'on', the UE shall not expect to be configured with CSI-RS over the symbols during which the UE is also configured to monitor the CORESET.  However, RAN1 doesn't specify any UE behaviour definition/expectation for measurement on CSI-RS without QCL indication. It is up to UE implementation and no need to specify UE behaviour. |
| CATT | Our understanding is that no UE behaviour restriction is specified in RAN1, and it is up to UE implementation. |
| InterDigital | No specific UE behaviour definition/exception has been defined for the case |
| Intel | According to our understanding, RAN1 specification doesn’t support resource prioritization rules or default QCL assumption for the cases when the QCL sources is not configured for CSI-RS |
| OPPO | No, there is no UE behaviour specified for that in RAN1. It is up to UE implementation. |
| Nokia, NSB | No, this is up to UE implementation |
| Qualcomm | UE behaviour is not defined |

***Summary on August 19:***

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| Moderator: In response to vivo, RAN4 is asking whether there is UE behaviour definition/expectation for P1 CSI-RS without QCL indication and whether there is UE behaviour definition/expectation for SSB. This is also confirmed by the contact person of this RAN4 LS.  ***Question 2:*** Whether there is UE behaviour definition/expectation when P1 CSI-RS QCL relation is configured as ‘none’ and to SSB? For example: are resource prioritization rules or default QCL assumption rules when overlapped with other resources (e.g. PDCCH, DMRS) established for both scenarios?  Yes (5 companies)   * UE is expected to try different Rx beams without assuming that gNB is transmitting with the same Tx beam: Huawei, HiSilicon, FutureWei * Similar to SSB within SMTC: ZTE * RAN1 spec implies that CORESETs other than CORESET#0 can be indicated as TypeD QCLed to a CSI-RS without QCL reference: Samsung   No (10 companies)   * UE implementation: Apple, vivo, LG, MediaTek, CATT, InterDigital, Intel, OPPO, Nokia, NSB   Other: MediaTek (UE shall not expect to be configured with CSI-RS with *repetition* set to 'on' over symbols during which UE is configured to monitor PDCCH) |

***Question 3:*** Whether CSI-RS for beam management as the first level of beam measurement/indication in connected mode is specified if it has no QCL relation to SSB?

***Views:***

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| Huawei, HiSilicon | In our understanding, in CONNECTED mode, CSI-RS for beam management without QCL relation to SSB being used as first level of beam measurement/indication are supported (related RAN1 specifications are listed in [R1-2006939](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006939.zip) for easier checking). |
| Apple | No |
| FUTUREWEI | Our view is that this is supported. |
| vivo | We are confused by the terminology “first level of beam measurement/indication”.  If it means whether UE could be configured with RS without QCL, our understanding is that this is not well defined in RAN1 spec. We prefer not to say this is supported in Rel-15/16. |
| LG | We have the same confusion as vivo on the terminology. To our understanding, there is no specified behaviour for the BM CSI-RS with no QCL info but it is allowed by the specification, so it is up to gNB/UE implementation how to use the configuration, e.g. for P-2 across multi-TRP as explained above from Rel-15. |
| ZTE | Support. This kind of CSI-RS is similar to SSB as we mentioned in Q2, and consequently it can be the first level of beam measurement/indication in connected mode. |
| Samsung | It is supported in our understanding. |
| MediaTek | It is supported but it is not needed to specify any related behaviour for it in specification. |
| CATT | It is supported in our understanding. |
| InterDigital | It is supported in our understanding. |
| Intel | RAN1 can clarify that from specification perspective CSI-RS for beam management can be used as QCL type D source RS in TCI state. There is no requirement in this case to have QCL type D source RS for that CSI-RS. |
| OPPO | In our understanding, CSI-RS for beam management without QCL relation to SSB can be used in beam measurement and indication. A CSI-RS without QCL relation to SSB can be configured in beam measurement and reporting. A CSI-RS without QCL relation to SSB can be configured as QCL type D source in TCI state.  However, there is no term called “the first level of beam measurement/indication” in RAN1 specification. |
| Nokia, NSB | It is supported |
| Qualcomm | CSI-RS for beam management without being QCLed SSB can be used for beam measurement and indication |

***Summary on August 19:***

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| Moderator: In response to vivo/LG, my understanding of ‘first level of beam measurement/indication’ in RAN4 question is about using ‘CSI-RS for BM without being QCLed to SSB’ for beam measurement and subsequent beam indication purposes.  ***Question 3:*** Whether CSI-RS for beam management as the first level of beam measurement/indication in connected mode is specified if it has no QCL relation to SSB?  Yes (13 companies): Huawei, HiSilicon, FutureWei, LG, ZTE, Samsung, MediaTek, CATT, InterDigital, OPPO, Nokia, NSB, Intel  No (2 companies): Apple, vivo |

# Proposed answers to RAN4

***Draft on August 19:***

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| ***Question 1:*** Does RAN1 consider it valid scenario(s) that P1 CSI-RS has no QCL relation for Rel-16? If valid, what are the corresponding usage scenarios? Has RAN1 analysed impact on UE mobility, scheduling restriction and overhead, UE power consumption, etc., with respect to number of active TCI states?  ***Answer 1:*** RAN1 consider P1 CSI-RS without QCL relation as valid scenario(s) in Rel-16. Corresponding usage scenarios include P1 beam alignment (similar as SSB), multi-TRP transmission with TRP not sending SSB, and inter-cell cooperation. Similar as other BM cases, RAN1 did not analyse impacts on UE mobility, scheduling restriction and overhead, and UE power consumption.  ***Question 2:*** Whether there is UE behaviour definition/expectation when P1 CSI-RS QCL relation is configured as ‘none’ and to SSB? For example: are resource prioritization rules or default QCL assumption rules when overlapped with other resources (e.g. PDCCH, DMRS) established for both scenarios?  ***Answer 2:*** For P1 CSI-RS without QCL relation and for SSB, there is no UE behavior/expectation explicitly defined in RAN1, and hence it is up to UE implementation.  ***Question 3:*** Whether CSI-RS for beam management as the first level of beam measurement/indication in connected mode is specified if it has no QCL relation to SSB?  ***Answer 3:*** CSI-RS for beam management without being QCLed SSB can be used for beam measurement and indication. To be specific, CSI-RS for beam management without being QCLed SSB can be included as QCL TypeD reference RS in a TCI state (to be indicated for e.g., PDCCH), and there is no requirement in this case to have QCL TypeD reference RS for this CSI-RS. |

# References

1. R1-2006952, “LS on CSI-RS only beam correspondence”