**3GPP TSG RAN WG1 #103-e R1-200xxxx**

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

**Source: Intel Corporation**

**Title: Summary#2 of AI: 8.1.2.4 Enhancements on HST-SFN deployment**

**Agenda item: 8.1.2.4**

**Document for: Discussion and Decision**

# Introduction

In RAN#86 meeting the work item on enhanced MIMO support was agreed for Rel-17 [1]. The objectives of WID include enhancements to multi-TRP transmission scheme in HST-SFN scenario.

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| 2. Enhancement on the support for multi-TRP deployment, targeting both FR1 and FR2:  …  d. Enhancement to support HST-SFN deployment scenario:  i. Identify and specify solution(s) on QCL assumption for DMRS, e.g. multiple QCL assumptions for the same DMRS port(s), targeting DL-only transmission  ii. Evaluate and, if the benefit over Rel.16 HST enhancement baseline is demonstrated, specify QCL/QCL-like relation (including applicable type(s) and the associated requirement) between DL and UL signal by reusing the unified TCI framework |

The document contains summary of the company’s proposal and FL proposals.

# Possible enhancements for HST-SFN deployment

The section summarizes company proposals regarding enhancements that can be supported for HST-SFN deployment. The proposals are based on the contributions [2]-[21] submitted to RAN1#103-e meeting.

## UE-based solutions

In RAN1#102-e meeting the following agreements were made regarding support of UE based solution for frequency offset compensation in HST-SFN scenario.

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| **Agreement**  For the discussion purpose consider the following categorization of the enhanced DL transmission schemes   * **Scheme 1**:   + TRS is transmitted in TRP-specific / non-SFN manner   + DM-RS and PDCCH/PDSCH from TRPs are transmitted in SFN manner * **Scheme 2**:   + TRS and DM-RS are transmitted in TRP-specific / non-SFN manner   + PDSCH from TRPs is transmitted in SFN manner   **Agreement**  Study the following aspects of the enhanced transmission schemes:   * **For scheme 1**:   + Target DL physical channels, i.e., PDSCH only or PDSCH + PDCCH   + Whether more than 2 QCL/TCI states are required and corresponding signaling details   + Whether and how to indicate scheme 1 for differentiation with Rel-16 non-SFNed transmission schemes with multiple QCL/TCI states   + QCL relationship between TRS and DMRS ports   + Note: Other schemes/aspects are not precluded * **For scheme 2**:   + Association of each MIMO layer of PDSCH to DM-RS antenna ports   + Whether more than 2 QCL/TCI states are required and corresponding signaling details   + Whether and how to indicate scheme 2 for differentiation with Rel-16 non-SFNed transmission schemes with multiple QCL/TCI states   Note: Other schemes/aspects are not precluded |

## Issue #1-1 (Support of scheme 1)

Regarding support of scheme 1 in Rel-17. Several companies expressed their preference on this issue. Some companies also provided LLS results comparing performance of scheme 1 with the baseline transmission scheme. Summary of the company’s views on support of scheme 1 in Rel-17 is provided below:

**Issue#1-1:** Whether to support scheme 1 in Rel-17?

* Scheme 1 is supported
  + Futurewei, Huawei, HiSilicon, ZTE, CATT (?), CMCC, Samsung, OPPO, Sony, Apple, LGE, Spreadtrum, DOCOMO, Qualcomm, Intel
* Scheme 1 is not supported
  + vivo
* Further study support of scheme 1
  + Nokia, Ericsson, Lenovo/MotM

Based on the company’s preference above, there is majority companies that prefers specification of scheme 1 in Rel-17 for HST-SFN scenario. Therefore, the following proposal is made:

**Proposal 1-1:**

* *Scheme 1 is supported in Rel-17*
  + *DMRS port(s) can associate with multiple QCL/TCI*
  + *FFS other details*

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| **Company** | **Comment** |
| CATT | Support this proposal. |
| vivo | We don’t agree with this proposal for following reasons:   * According to simulation results, it’s observed that NW based solution(i.e. frequency shift pre-compensation) outperforms two UE based solutions(i.e. scheme1 and scheme2). * If NW based solution and UE based solution are both supported in Rel-17, a Rel-17 UE may need to support both conventional U-shape time-domain filter for NW based solution and advanced time-domain filter based on reconstructing the Doppler shift spectrum for scheme 1, that would increase the complexity of UE. Otherwise, there would still be some misalignment(same as LTE) between gNB and UE, especially in the case that NW doesn’t enable frequency shift pre-compensation, while UE also doesn’t support the advanced time-domain filter capability for DMRS estimation. That will cause the degradation of UE demodulation performance.   However, we agree that ***DMRS port(s) can associate with multiple QCL/TCI*** in Proposal 1-1, since that is also necessary for NW based solution. |
| Huawei, HiSilicon | Support FL proposal.  For vivo’s comment, whether support TRP-specific TRS?  Further reply: From the companies’ view, no matter UE based solution and TRP based solutions, we need to agree the common part to progress:  ***Proposal 1-1: Support at least the following configurations for HST scenarios:***   * ***TRS is transmitted in TRP-specific / non-SFN manner*** * ***DM-RS and PDCCH/PDSCH from TRPs are transmitted in SFN manner***   Whether UE based or TRP based, we can further decided the following steps. Most companies already provided evaluation results which is agreed in last meeting, we do not think it need to be discussed again and again.  **Further comments to Erisson:**  The evaluation should be based on the agreed EVM, while the baseline is SFN transmission ( which is also used in practical scenarios).  Then, for the evaluation itself in Fugure 8 in R1-2009523 from Ericsson, we are curious that why DPS is a flat curve no matter of distance from TRPs?   * If the SNR is assumed from transmit side for the closest TRP, then DPS will be with performance degradation when increasing of distance from closest TRP.   If the SNR is assumed in receive side from closest TRP, then the received power for SFN based solution should be more in the middle point of the TRPs, since additional power can be achieved from another TRPs especially with frequency pre-compensation, i.e, the curve for SFN should be concave. |
| Docomo | Support the FL proposal. We prefer to support both NW based solution and UE based solution in Rel.17. In UE based solution, many companies shows evaluation result to compare Scheme 1 and Scheme 2, and Scheme 1 outperforms Scheme 2 due to the DMRS overhead. Hence, we can select Scheme 1 as a single solution of UE based solution. |
| Spreadtrum | Support FL proposal. |
| vivo | For Huawei, HiSilicon’s comment, we support TRP-specific TRS, which is also necessary for NW based solution.  We just notice that supporting both UE based solution and NW based solution would cause misalignment which is mentioned above. To avoid the misalignment and reduce the UE complexity, we suggest choosing only one scheme for Rel-17 HST-SFN, and we prefer NW based solution due to its better performance. |
| OPPO | Support.  In our understanding, scheme 1 and “DMRS port(s) can associate with multiple QCL/TCI” are the same thing from standardization. So we fail to understand why vivo can’t agree on scheme 1. |
| Sony | Confirm that we are fine to Scheme 1 and support Proposal 1-1 from FL. |
| ZTE | Support this proposal.  We share the same view with majority companies. UE based and NW based solution are implemented from different perspective. Both two features will be optional. If UE vendors have concern on complexity, one of them can be chosen.  Suggest the slight change as follows  **Proposal 1-1:**   * *Scheme 1 is supported in Rel-17*   + *The same PDSCH DMRS port(s) can associate with multiple QCL/TCI*   + *FFS other details* |
| Samsung | Support FL proposal. Besides, we suggest to clarify more on the other details, which can be a guidance for future meetings. We think the most important thing is the signaling mechanism to indicate multiple TRS. Hence, we suggest to add that part in the last sub-bullet as follows:   * *Scheme 1 is supported in Rel-17*   + *DMRS port(s) can associate with multiple QCL/TCI*   + *FFS Detailed mechanism to signal multiple QCL/TCI to DMRS port(s) and other details* |
| LG | Support this proposal. |
| Nokia/NSB | It is better to first agree on supporting distributed TRS, which is necessary for both scheme 1 and scheme 2. This proposal does not allow for only scheme 2 to be supported. We feel support for scheme 1 and/or scheme 2 must be considered together rather than separately. |
| Ericsson | Our simulation with the agreed CDL-D model shows that DPS provides the best performance. Therefore, we think it is premature to select scheme 1 or other schemes in this meeting. In the current evaluations presented by some companies, some of the evaluation assumptions are not clearly stated. Hence we would like companies to elaborate more about their simulation setups: number of retransmissions, antenna tilt direction (towards middle point of the 2 TRP or other direction), 2 or 4 TRPs used in the extended CDL channel model, antenna pattern, and precoding methods for PDSCH. It is better to further clarify and align simulation assumptions among companies and to come back in the next meeting to compare results. |
| InterDigital | We have a similar view as Nokia that at this point we should first agree on non-SFN TRS, and then further study the proposed schemes as suggested by Ericsson. |
| CMCC | Support FL’s proposal.  Regarding vivo’s concern, both UE-based solution and network-based solution have performance gains and can be used and deployed based on different considerations, e.g., deployment scenarios, UE capability, etc, and UE will not be mandated to implement both of these two schemes. Regarding the receiver implementation of scheme 1 and scheme 2, it is also not sure UE has to implement two significant different filters for scheme 1 and scheme 2.  Regarding another point ‘misalignment(same as LTE) between gNB and UE’, I think it is talking about the scenario where both Rel-17 and Rel-15/16 Ues exist in the network, it can be up to network to configure a SFN-based TRS for the legacy Ues to address this concern. |
| Lenovo/MotM | We agree with Nokia, Ericsson, InterDigital that it is pre-mature to make a decision on Scheme 1 independently. A joint decision should be made on selection between Scheme 1 or Scheme 2, as well as whether we need to incorporate the Frequency pre-compensation scheme with either Scheme 1or Scheme 2 |
| NEC | We share similar view with Nokia, Ericsson, InterDigital and Lenovo, Scheme 1 and 2 should be considered together. |
| Apple | Fine with the FL proposal |
| vivo | For CMCC’s comment on ‘misalignment(same as LTE) between gNB and UE’, here the misalignment means that a Rel-17 gNB doesn’t support/enable frequency shift pre-compensation while unfortunately a Rel-17 UE doesn’t support the advanced time-domain filter capability for scheme 1 either. Then gNB can only configure a SFN-based TRS for this UE, which leads to poor performance as Rel-15/16. We just want to prevent this situation from happening.  In our opinion,   * If both UE based solution and NW based solution are supported in Rel-17, it still cannot be guaranteed that a Rel-17 gNB would support the frequency shift pre-compensation feature and a Rel-17 UE would support the advanced time-domain filter capability for scheme 1 in practice, it depends on gNB/UE vendors. But if we just specify only one scheme for Rel-17 HST-SFN, the misalignment mentioned would not happen. * Moreover, the frequency shift pre-compensation outperforms scheme 1 as shown in our simulation results[5]. We think supporting NW based solution (i.e. frequency shift pre-compensation) is enough.   Besides, we agree that DMRS port(s) can associate with multiple QCL/TCI in Proposal 1-1, and we believe that is a common standpoint. DMRS port(s) associating with multiple QCL/TCI is not only necessary for scheme 1, but also for frequency shift pre-compensation. Therefore, we suggest modifying Proposal 1-1 as follows:  **Proposal 1-1:**   * *~~Scheme 1 is supported in Rel-17~~* * *The same DMRS port(s) can associate with multiple QCL/TCI*    + *FFS other details* |
| Intel | Support FL proposal. Agreement on the support of scheme 1 is required for further discussion on QCL aspects. It is better not to mix discussion with support of other schemes as the requirements (e.g. SRS transmission in all DL serving cells) and UE/NW impact are different. |
| Futurewei | Support the FL’s proposal |
| Qualcomm | In our analysis, we compared the performance of Scheme-1 versus Scheme-2 at both channel models and for different DL transmission ranks and for both scenarios with and without pre-compensation.   * Our evaluation suggest that scheme-1 at least outperform scheme-2. * Also, from spec-impact point of view, we don’t see the need to support both schemes as scheme-2 requires much more spec impact than scheme-1 without any proven gain or advantages. * For scheme-2 with pre-compensation, the advantages of better channel quality are no longer valid.   We think in this meeting (103-e), we should first down select between Scheme-1 and Scheme-2, then we can compare the better scheme against the baseline(s), e.g. Rel-15 purse SFN, DPS and M-TRP SDM scheme.  Given the above, *we support scheme-1 over scheme-2 as a* ***‘candidate’*** *for HST-SFN enhancement in Rel-17* *and suggest further analysis and study with other baseline schemes.* |
| FL | **Observations**:   * Based on the company’s feedback, there is clear majority (16) that prefers specification of scheme 1 in Rel-17. * Several companies (6) prefer to take a joint decision on support of scheme 1 and scheme 2. However, based on the feedback received for proposal 2-1, it seems scheme 2 requires further study on possible DM-RS overhead reduction options to improve performance comparing to scheme 1. It is, therefore, proposed to discuss way forward for scheme 2 separately. * Two companies suggested modifications to simulation assumptions and in conjuction with that proposal expressed preference to further study performance of scheme 1. However, it is unlikely that situation wrt to preference would be different in the next RAN1 e-meeting. Moreover, updates to simulation assumption would require another round of discussion, which seems not feasible from WID time mamangement. * One company also mentioned commonalities between scheme 1 and TRP based pre-compensation wrt to association of DM-RS port(s) with multiple QCL/TCI.   Based on the discussion above FL recommends to agree on original FL proposal #1-1 or updated FL proposal #1-1:   |  | | --- | | **Updated proposal 1-1:**   * *Support at least the following configuration for HST scenario in Rel-17*   + *DMRS port(s) can associate with multiple QCL/TCI*      - *FFS other details* |   FL wants to remind RAN1 about the objective for HST-SFN deployment:   |  | | --- | | 2. Enhancement on the support for multi-TRP deployment, targeting both FR1 and FR2:  …  d. Enhancement to support HST-SFN deployment scenario:  i. Identify and specify solution(s) on QCL assumption for DMRS, e.g. multiple QCL assumptions for the same DMRS port(s), targeting DL-only transmission | |
| OPPO | We are in principle fine with the updated proposal. However, DMRS port(s) associated with multiple TCI states has been supported in Rel-16 for URLLC scheme 2a/2b/3/4. To differentiate with the Rel-16 enhancements, we propose some rewording below:   * *Support at least the following configuration for HST scenario in Rel-17*   + *The same DMRS port(s) can associate with multiple QCL/TCI*      - *Note: DM-RS and PDCCH/PDSCH from different TRPs are transmitted in SFN manner*     - *FFS other details* |
| Intel2 | Reagrding E/// evaluation results.  On deployment scenario shown in Figure 1. Is it correct understanding that 4 TRP has antenna array pointing to the mid track position between second and third TRP? According to our understanding, extension to 4 TRS deployment should have each site equipped with two antenna array pointing to almost opposite directions to the center of the mid track position between two neighboring sites of TRPs as shown in figure below. In such scenario we should expect negligible ISI impact.    On DPS. SFN offers ~3dB gain over DPS, which offers large inter TRP distance in the deployment. We are not sure how DPS could outperform SFN in this case.  Regarding vivo comment that TRP pre-compensation is simpler and more efficient solution comparing to scheme 1/2.  We are not sure it is the case. In particular if we consider time domain pre-compensation, certain physical channel multiplexing becomes problematic, e.g. SSB with unicast PDSCH. No transmission of PDSCH would have negative impact on the UE throughout. There is no such issue for scheme 1. Moreover, TRP based pre-compensation requires SRS transmission on each serving cell. We are not sure typical UE implementation has such advance CA capability. Therefore, we prefer to agree on support on scheme 1 (in addition to TRP based pre-compensation), since it has some advantages over TRP-based pre-compensation. |
| Ericsson | Thanks Intel for the questions.  On deployment scenario shown in Figure 1. Is it correct understanding that  4 TRP has antenna array pointing to the mid track position between second and third TRP?  E///: Yes, the default orientation and downtilt of the array is such that it points to a **UE at midpoint between adjacent sites**. Additionally, we have provided results for 10 deg. downtilt, which is 5 deg. larger than the default downtilt.  According to our understanding, extension to 4 TRS deployment should have each site equipped with two antenna array pointing to almost opposite directions to the center of the mid track position between two neighboring sites of TRPs as shown in figure below. In such scenario we should expect negligible ISI impact.  E///: We have considered one antenna array at each site pointing towards the **mid-point of adjacent sites as shown in Figure 1**. The results shown in Figures 3—5 used a f-direction filter size of 50 PRBs, when we reduced the filter size to 1—2 PRBs, the throughput performance at 175 m and 525 m improved, thereby showing that the impact of ISI at these locations is smaller than what we previously thought.  On DPS. SFN offers ~3dB gain over DPS, which offers large inter TRP distance in the deployment. We are not sure how DPS could outperform SFN in this case.  E///: We have plotted throughput as a function of SNR at D1=0m. In case of DPS, the SNR calculation assumes that only one TRP is active when computing reference gain at D1= 0. While, for SFN it assumes that all 4 TRPs are active when computing reference gain at D1=0. Therefore, the SNR gain at each UE location shown in our figures did not reflect the 3 dB gain. We have now added results for DPS where the SNR at D1=0m in SFN deployment is used as a reference to compute the SNR gain at each UE location.  As we started to look into the details of simulations, we would like to ask questions here to understand the simulation results shown in some of the contributions. We would appreciate if those information can be provided.  Huawei: R1-2007590   1. Definition of SNR shown in the figures: is it ‘SNR closest to RRH ‘ 2. Extended CDL channel model: 2-TRP or 4-TRP 3. Which antenna pattern is used. What is the precoding method used 4. How many retransmissions are used   QC: R1- 2009254   1. “The DL precoder is random precoder cycling per each TRP with PRG = 2RB”: do you have results for a legacy UE when precoder cycling is used 2. Extended CDL channel model: 2-TRP or 4-TRP 3. How many retransmissions are used   ZTE: R1-2007767   * How many retransmissions are used |
| Nokia/NSB | We appreciate the FL’s reminder on the objective but note that supporting . multiple QCL assumptions for the same DMRS port(s) may not be needed for scheme 2. Therefore, we feel it is necessary to first agree on the what is common for all UE-based and network-based schemes or otherwise downselect the scheme(s) that will be supported. |

Please find updated proposal according to comment from OPPO:

**Updated proposal 1-1:**

* *Support at least the following configuration for HST scenario in Rel-17*
* *The same DMRS port(s) can associate with multiple QCL/TCI* 
  + *Note: DM-RS and PDCCH/PDSCH from different TRPs are transmitted in SFN manner*
  + *FFS other details*

## Issue #1-2 (Target physical channels)

Regarding target physical channels. Some companies provided their views regarding target physical downlink channels to supported for scheme 1 between the following options – PDSCH only or PDSCH + PDCCH. Summary of the company’s preference is provided below:

**Issue#1-2:** Physical channels that should be supported for scheme 1

* PDSCH only
  + Huawei (?)
* PDCCH + PDSCH
  + Futurewei, vivo, CMCC, Samsung, Sony, LGE, DOCOMO, Qualcomm (wait progress on mTRP PDCCH), Intel

Based on the company’s preference above, there is majority that prefers specification of scheme 1 for both PDSCH and PDCCH. Therefore, the following proposal is made:

**Proposal 1-2:**

* *Scheme 1 is supported for both PDCCH and PDSCH*

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| **Company** | **Comment** |
| CATT | PDSCH should be treated with higher priority. The enhancement on PDCCH can be suspended in this session since there is a parallel sub-agenda on PDCCH enhancement for M-TRP. |
| Huawei, HiSilicon | Suggest to focus on PDSCH first and discuss about them separately since they have different spec impacts. For exampling, for PDSCH, Rel-16 mechanism can already support two TCI states activation through MAC CE and spec efforts can be minor, but for PDCCH, the mechanism itself needs to be designed in Rel-17. Also, it seems most companies only provided performance for PDSCH.  **Further reply:**  From the reply, most companies are fine with PDSCH with priority, but for PDCCH, still some concerns and confilict discussion with PDCCH enhancement topic. So, anyway, it should be treated later, we require more evaluation and comparison on PDCCH before it is supported. Suggest to following adjustment:   * *Scheme 1 is supported for ~~both PDCCH and~~ PDSCH with priority* * *PDCCH will be discussed later* |
| DOCOMO | Support FL proposal |
| OPPO | Agree with HW to focus on PDSCH firstly. For PDCCH, further evaluation maybe needed after enhancement for PDSCH is specified. |
| Sony | Support Proposal 1-2 from FL. |
| ZTE | Support |
| Samsung | Support |
| LG | Support this proposal. The detail configuration for CORESET and search space to support SNFed PDCCH can be discussed further in 8.1.2.1 MTRP PDCCH. |
| Nokia/NSB | We need to first agree to support scheme 1. |
| Ericsson | As we commented in proposal 1, it is premature to make decisions in this meeting for both PDSCH and PDCCH. |
| InterDigital | In our view, based on the last meeting agreement, PDCCH was already supported by Scheme 1. |
| CMCC | Support the proposal |
| Lenovo/MotM | Agree with CATT, LG, PDSCH should be prioritized. More importantly, PDCCH enhancements may interfere with the decisions in AI 8.1.2.1, and shouldn’t be discussed until some progress is made there |
| Apple | We can prioritize PDSCH, PDCCH has DMRS in every symbol and only relatively low SE. Furthermore, if we discuss PDCCH enhancement, we also need to discuss whether we enhance PDCCH that is used for initial acquisition which UE anyway cannot be mandated to support |
| Intel | Support FL proposal if PDCCH inherits PDSCH scheme with no or minimum modification. |
| Futurewei | Support the FL’s proposal |
| Qualcomm | SFN PDCCH in HST scenario is a special case of SFN transmission in general. There could be some other scenarios e.g. cell edge UE with low-mobility environment where NW may decide to transmit SFNed PDDCH for increase reliability.  We think that if it was decided to support enhanced SFN transmission, then both PDSCH and PDCCH should be supported to have a complete framework. However, given the current discussion of PDDCH reliability enhancement in M-TRP (8.1.2.1), we should hold on the discussion till some progress made there. |
| FL | **Observations**:   * Most of the companies supports scheme 1 for PDCCH and PDSCH with prioritization of the work for PDSCH. * If scheme 1 is agreed to be supported for PDCCH, some discussion is required, which agenda item should address the remaining details taking into account HST-SFN scenario * 8.1.2.1 * 8.1.2.4   Based on the summary above FL recommends to agree on FL proposal 1-2 or updated FL proposal 1-2   |  | | --- | | **Updated proposal 1-2:**   * *Scheme 1 is supported for both PDCCH and PDSCH*   + *PDSCH is considered with higher priority* | |
| Nokia/NSB | The updated proposal 1-2 is premature since there is no agreement to support scheme 1 even based on the updated proposal 1-1. We suggest the following modification:  **Updated proposal 1-2:**   * *~~Scheme 1 is supported~~Support of scheme 1 is considered for both PDCCH and PDSCH*   *PDSCH is considered with higher priority* |
| Lenovo/MotM | We support the FL proposal |
| Nokia/NSB | Because Rel-16 Multi-TRP only supports indicating two TCI states for PDSCH. For applying this for PDCCH, we have to define further details on PDCCH TCI update and QCL assumption. In order to avoid multiple version of TCI/QCL framework, it is better to wait Rel-17 PDCCH enhancement for M-TRP. |

## Issue #1-3 (Number of QCL/TCI for scheme 1)

Regarding the number of QCL/TCI that should be supported for scheme 1. Several companies provided their preference on this issue. Summary of the company’s views is provided below:

**Issue#1-3:** The number of QCL/TCI states supported in scheme 1

* At most two QCL/TCI states can be configured/indicated for scheme 1
  + Futurewei, vivo, CATT, Samsung, OPPO, LGE, Spreadtrum, Qualcomm, Lenovo/MotM, CMCC
* Two or more QCL/TCI states can be configured/indicated for scheme 1
  + Intel, DOCOMO, Sony
* Further study
  + Ericsson, InterDigital

Based on the company’s preference above, there is majority that prefers support of at most two QCL/TCI states for scheme 1. Therefore, the following proposal is made:

**Proposal 1-3:**

* *At most two QCL/TCI states are supported for scheme 1*

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| **Company** | **Comment** |
| CATT | Support this proposal. |
| Vivo | Support at most two QCL/TCI states. Besides, we think that two QCL/TCI states are also enough for NW based solution. We prefer to finally modify Proposal 1-3 as *At most two QCL/TCI states are supported.* |
| Huawei, HiSilicon | OK |
| DOCOMO | For progress, we are fine with FL proposal. |
| Spreadtrum | Support |
| OPPO | Fine with the proposal. |
| Sony | Different from M-TRP based PDCCH/PDSCH (up to 2 TRPs), SFN scheme(s) are strived to be designed with as less standard impact as possible, though it’s not perfectly standard transparent. We think it might be pre-mature to put the same constraints on maximum number of QCL/TCI states to 2, and it could be beneficial in performance-wise to involve more than 2 TRPs serving UE in SFN manner. |
| ZTE | Support |
| Samsung | Support |
| LG | Support this proposal |
| Nokia/NSB | We need to first agree to support scheme 1. It is too early to agree to this. |
| Ericsson | As we commented in proposal 1, it is premature to make decisions in this meeting for both PDSCH and PDCCH. |
| InterDigital | Need to agree on the general schemes first before discussing next step details. |
| CMCC | Support |
| Lenovo/MotM | Support |
| Apple | Support |
| Intel | Our preference is more than two TCI states. UE selection of TRS in scheme 1 is autonomous and this would help minimizing ignalng overhead associated with two TCI reconfiguration. |
| Futurewei | Support the FL’s proposal.  We are also fine with considering more TCI states (subject to network configuration and UE capability in practice) |
| Qualcomm | We support the FL proposal to limit the QCL/TCI states to only two. The support of more than 2 QCL/TCI states should be justified. |
| FL | **Observations**:   * Majority of companies supports FL proposal on at most two QCL/TCI states   FL recommends to agree on FL proposal 1-3 |
| Nokia/NSB | We suggest the following modification to the updated proposal.  **Proposal 1-3:**  *At most two QCL/TCI states are supported for scheme 1 (if supported)* |

**Updated proposal 1-3:**

* *At most two QCL/TCI states are supported for DM-RS for HST scenario in Rel-17*
  + *FFS configuration/signalling details of the QCL/TCI states*

## Issue #1-4 (Indication of scheme 1 / 2)

Regarding configuration or switching of scheme 1. Several companies provided their preference regarding support of dynamic switching between scheme 1 / scheme 2 (if supported) and Rel-16 non-SFN schemes. Summary of the company’s preference is provided below:

**Issue#1-4:** How to support configuration / switching between Rel-17 scheme 1 or scheme 2 (if supported) and Rel-16 schemes?

* DCI
  + Futurewei, vivo, Samsung, LGE, Qualcomm
* MAC CE
  + Futurewei
* RRC
  + Futurewei, InterDigital, ZTE, CMCC, OPPO, Ericsson, Lenovo/MotM, Spreadtrum, Qualcomm, DOCOMO (prefer to discuss later), Sony

Given the views above, there is no majority to support DCI based switching in RAN1#103-e. At the same time, it should be common understanding that at least some RRC signalling is required to enable scheme 1 or scheme 2 (if supported). Therefore, the following proposal is made:

**Proposal 1-4:**

* *At least RRC is used to enable scheme 1 / scheme 2 (if supported)*
  + *FFS whether or not DCI based dynamic switching with Rel-16 non-SFN scheme(s) is supported*
  + *FFS which Rel-16 non-SFN schemes should be supported for dynamic switching*
  + *Note: Support of scheme 1 or scheme 2 is a different issue and should be discussed separately*

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| **Company** | **Comment** |
| CATT | In our view, the issue of differentiation between schemes is the next-level detail , and should be discussed later, |
| vivo | We think it can be discussed after determining the final solution for Rel-17 HST-SFN. |
| Huawei, HiSilicon | Not support, since we do not need two schemes for the same use case, while Scheme-2 is no obvious gain can be observed.  Further reply:  Yes, it should be later handle after Scheme-1 and 2. Actually, it is only signaling design, normally will be discussed after finalized schemes. |
| DOCOMO | Agree with CATT and vivo. We can discuss the configuration after we define the UE behavior. So fat, we think RRC based configuration is enough.  We understand the proposal 1-4 is valid, if only scheme 1 is supported. |
| Spreadtrum | Not support |
| OPPO | We are fine to discuss it after scheme 1 is agreed, though we support the proposal in principle. |
| Sony | In our understanding, either of scheme 1 and scheme 2 (if supported) can be semi-statically configured. There seems no strong motivation to dynamically switch between these two schemes in a HST scenario.  In addition, since in Issue #1-1, only scheme 1 has clear majority support, so it might be too early to discuss the differentiation. If only scheme 1 supported, then we don’t have to discuss the next-level details on how to smoothly support both schemes. |
| ZTE | Honestly, we don’t think scheme 2 should be supported. So prefer deprioritizing this proposal. |
| Samsung | It seems that the two issues are mixed in this proposal. The first issue is how to configure Scheme ½, and the second issue is whether to support or not dynamic switching of Scheme ½ and others. We suggest to separate those issues. |
| LG | We have similar view with vivo. The signaling details can be discussed after decision on the schemes. |
| Nokia/NSB | Do not support the proposal.  We need to first agree on which scheme(s) is (are) supported. It is also not clear why there is need to agree on two schemes to do the same thing |
| Ericsson | We think this is the next level of details and should be discussed later |
| InterDigital | Same view as Samsung, two different issues seem to be mixed here.  Switching behavior between agreed schemes should be different from switching between Rel-16 non-SFN and Rel-17 SFN. |
| CMCC | Can be discussed after we have a decision on whether scheme 2 will be supported or not |
| Lenovo/MotM | We support the FL proposal. We suggest a minor edit “*At least RRC is used to enable scheme 1 and****/or*** *scheme 2 (if supported)*” to remove the ambiguity |
| Apple | We prefer RRC |
| Intel | RRC seem sufficient, but OK to study dynamic in the next meeting. |
| Futurewei | We are fine with the FL’s proposal. We are also open for other views. |
| Qualcomm | This proposal should be discussed later after we down-select between the two candidate SFN schemes. However, we are open for the discussion of both semi-static and dynamic indication. |
| FL | **Observations**:   * It seems there is some misunderstanding about original FL proposal. Per one company suggestion the proposal 1-4 is modified to resolve this ambiguity:  |  | | --- | | **Updated proposal 1-4:**   * *At least RRC is used to enable scheme 1 and / or scheme 2 (if supported)*   + *FFS whether or not DCI based dynamic switching with Rel-16 non-SFN scheme(s) is supported*   + *FFS which Rel-16 non-SFN schemes should be supported for dynamic switching*   + *Note: Support of scheme 1 or scheme 2 is a different issue and should be discussed separately* |  * As indicated by several companies, the proposal 1-4 to be discussed after agreement on support of scheme 1 and/or 2 is made. |
| Nokia/NSB | We are fine with the updated proposal. |
| Lenovo/MotM | Support the FL proposal |

## Issue #1-5 (QCL relationship between TRS and DMRS ports)

On the aspect of “QCL relationship between TRS and DMRS ports”, one company [7] proposed to extend definition of QCL to support QCL association of one antenna port (e.g., DM-RS) and antenna port group (e.g., TRS).

**Issue#1-5:** Whether or not to modify QCL definition to support QCL association relationship of one antenna port and one antenna port group?

|  |
| --- |
| Antenna port x and antenna port group y are said to be quasi co-located if the large-scale properties of the channel over which a symbol on antenna port x is conveyed can be inferred from the combination of channels over which the symbols on the antenna ports of the antenna port group y is conveyed. The large-scale properties include one or more of delay spread, Doppler spread, Doppler shift, average gain, average delay, and spatial Rx parameters. |

This aspect has been listed as open issue from RAN1#102-e meeting. It is recommended to have further discussion on this issue.

**Proposal 1-5:**

* *Companies to provide their views on this issue.*

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| --- | --- |
| **Company** | **Comment** |
| CATT | In Rel-15 and Rel-16, the definition of QCL is a relationship between two antenna ports. For scheme 1, the large-scale property of the channel for a DMRS port can be inferred from the combined channel of multiple TRS ports, and the large scale property of the channel for any TRS port within the set of TRS ports cannot be inferred from the channel for the DMRS port. Therefore, according to the definition of QCL in Rel-15, we can’t say a TRS port within the multiple TRS ports is QCL-ed with the DMRS port. A new definition on QCL is needed. |
| Huawei, HiSilicon | In our understanding, the QCL definition is for some channel properties from one port to another port. But, the target port/resource can have multiple source resource/ports, such as CSI-RS 1 for Type A QCL for DMRS port, and CSI-RS 2 for Type D for DMRS port.  In HST Scheme-1, 2 TRS resources provide QCL for the same DMRS resource. The definition of QCL is no need to change, but the QCL mapping new QCL assumptions (discussed in 2.2.4 and 2.2.5) need to be updated. |
| Sony | In scheme 1, a large-scale channel properties of DMRS port can be inferred from multiple TRS ports. Out of curiosity, what would be use case for the other way around? For example, the large-scale channel properties of multiple TRS ports can be implied from DMRS port. |
| ZTE | Support to modify the definition for SFN scheme. Otherwise, the current definition of QCL seems inappropriate for SFN scheme.  The specific wording can be further discussed.  Proposal: Support to modify Rel-15/16 QCL definition between two ports.  ----------------------Rel-15.16 QCL definition for two ports------------------------  *Two antenna ports are said to be quasi co-located if the large-scale properties of the channel over which a symbol on one antenna port is conveyed can be inferred from the channel over which a symbol on the other antenna port is conveyed. The large-scale properties include one or more of delay spread, Doppler spread, Doppler shift, average gain, average delay, and spatial Rx parameters.* |
| Samsung | We don’t think this modification is necessary. It seems that the existing text “can be inferred” clearly states the relationship between x and y. If y consists of multiple ports, e.g., y1, and y2, channel property of x is inferred separately from y1 and y2 and there’s no need to additionally clarify that “x is inferred from combination of y1 and y2.” |
| Nokia/NSB | We don’t agree to this definition. This new definition does not specify how antenna port x is related to each antenna port in port group y, which we feel is still necessary. |
| Ericsson | It is true that the channel associated with each TRS cannot be inferred from the DMRS.  On the other hand, the TRS are to be specified only as the QCL resource RS for DMRS, i.e. the channel properties of the DMRS is to be inferred from the multiple TRS, there seems to be no conflict with the current QCL definition. |
| InterDigital | No re-definition of QCL is needed, however new QCL type(s) is needed. |
| Lenovo/MotM | We believe this is a valid point that needs further discussion in case Scheme 1 is adopted. |
| Apple | We are open to discuss. |
| Futurewei | New definition of QCL is needed, and there could be two different cases:   * Case 1: the “composite” channel from group y is considered.   We think “composite” channel is a better term than “combination” of channel, as it is widely used and well understood.  In the composite channel, all the taps / paths / multipath components are considered.   * Case 2: some properties are from the composite channel, but some other properties are from only one of the channels, or from the average of the two channels.   So for those other properties here, the target should use only one of the channels to infer (based on NW indication), or the target should use the average of the properties inferred from the two channels. |
| Qualcomm | It is implicitly understood that for DMRS port with more than one QCL types, the delay, Doppler, and Rx beams properties are obtained from both source RSs. So, we do not think there is a need to modify the QCL definition. |
| FL | **Observations**:   * It seems there is no majority to modify QCL definition (yes (including FFS) – 6; no – 9). * Further discussion is needed on this issue, possibly in the next RAN1 e-meeting. |

## Issue #1-6 (Support of scheme 2)

Regarding support of scheme 2. Several companies expressed their preference regarding support of scheme 2 in Rel-17. Some companies have also demonstrated LLS evaluation results comparing performance of scheme 2 with scheme 1 and the baseline scheme. Summary of the company’s views is provided below:

**Issue#1-6:** Whether to support scheme 2 in Rel-17?

* Scheme 2 is supported
  + InterDigital, NEC, LGE, Lenovo/MotM, Intel
* Scheme 2 is not supported
  + Samsung, vivo, Qualcomm, OPPO, Huawei, HiSilicon, DOCOMO, Sony
* Further study support of scheme 2
  + Nokia, Ericsson

There is no clear majority to support scheme 2 in Rel-17 for this meeting. Therefore, it is recommended to further study support of scheme 2 in the next meetings with the aim to address some technical concerns (e.g., DM-RS overhead).

**Proposal 1-6:**

* *Further discuss the need of supporting scheme 2 in Rel-17 including possible DM-RS overhead reduction options*

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| --- | --- |
| **Company** | **Comment** |
| CATT | Scheme 2 requires more DMRS overheads and more specification efforts. It should not be supported unless significant performance gain can be achieved compared to scheme 1. |
| Huawei, HiSilicon | Not support Scheme-2. No obvious gain compared to Scheme-1, but with more overhead compared Scheme-1. We show the performance comparison between Scheme-1 and 2 (R1-2007590), where Scheme-1 is much better than Scheme-2. |
| DOCOMO | Based on the simulation results by companies, Scheme 1 outperforms Scheme 2 due to the DMRS overhead. We prefer to select Scheme 1 as single solution of UE based solution. |
| OPPO | According to the evaluation results in our contribution, scheme 2 will suffer from DMRS overhead and lead to performance loss. It is not needed to support both schemes in Rel-17. |
| Sony | In our view, scheme 1 and scheme 2 mainly differs in whether PDCCH and PDCCH DMRS can be transmitted in SFN manner or not. So we tend to agree with CATT that if scheme 2 can significantly outperform scheme 1 with acceptable more standard effort, it can be further discussed. |
| ZTE | Don’t support this proposal. There is no clear benefit compared with scheme 1 from both performance and spec effort perspective. |
| Samsung | Okay to further discuss in the future, but with low priority. |
| LG | We prefer to support both scheme 1/2 for Rel-17 SFN transmission. In Rel-16, several schemes were introduced for mTRP based URLLC schemes, and each scheme has different advantages and disadvantages. Different schemes for Rel-17 SFN transmission can also be considered. For example, scheme 2 may not need higher UE capability for channel estimation compared to scheme 1 because each channel estimate for each TRP can be obtained based on the conventional channel estimation using single QCL reference RS. So, supporting both schemes will provide flexibility for UE implementation. |
| Nokia/NSB | Support for scheme 2 should not be considered independently from support for scheme 1. We feel support for scheme 1 and/or scheme 2 must be considered together rather than separately |
| Ericsson | Again, we think that more evaluation is needed for both schemes 1 and 2 |
| InterDigital | Further evaluation are needed, however at the end it may be that both schemes to be supported. |
| CMCC | Considering the simulation results, scheme 1 outperforms scheme 2 because of DMRS overhead, we support only support scheme 1. |
| Lenovo/MotM | We believe further evaluation is needed. As mentioned above, a joint decision should be made on selection between Scheme 1 or Scheme 2, as well as incorporating the Frequency pre-compensation scheme |
| NEC | We share similar view with Nokia, Ericsson, InterDigital and Lenovo, Scheme 1 and 2 should be considered together. |
| Apple | Fine with FL proposal |
| Intel | We prefer scheme 2 to be specififed, but we could study further if companies have concerns. |
| Futurewei | We are fine with the FL’s proposal |
| Qualcomm | We don’t support scheme-2. |
| FL | **Observations**:   * There is no clear majority to support scheme 2 in this e-meeting. * Some companies still see necessity for specification of scheme 2, but other companies mention drawback of larger DM-RS overhead that offsets performance gains. * The possible way forward would be to continuie study on support of scheme 2 for Rel-17 focusing on DM-RS overhead issue mentioned by several companies.   FL recommends proposal 1-6 as conclusion for the next RAN1 e-meeting. |

**Proposal 1-6 (for conclusion):**

* *Further discuss the need of supporting scheme 2 in Rel-17 including possible DM-RS overhead reduction options*

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| --- | --- |
| **Company** | **Comment** |
| ZTE | No need.  It has no performance benefit but cause extra spec complexity. Also, we may have SFN for PDCCH, scheme 2 does not work for PDCCH. |
| Huawei, HiSilicon | We also show no obvious benefits of Scheme-2 but consuming more DMRS resouces in our evaluation. So, not support Scheme-2. |
| Ericsson | We are fine with further study of scheme 2. |
| Futurewei | We are fine with further studying/discussing Scheme 2, but we understand the concerns, so we can be flexible and follow the majority view.  Our technical view is: With regard to Scheme 1 vs Scheme 2, Scheme 1 has a lower DMRS overhead but the channel estimation on the DMRS with a composite channel from all TRPs may be more complicated and less accurate than Scheme 2. In other words, the schemes can be used to achieve different tradeoffs, and hence may be preferred under different scenarios. To provide sufficient flexibility in standards, both schemes should be supported.  On the other hand, we also realize that to support Scheme 2, then the scheme differentiation and indication would be quite complicated, as shown in our tdoc.  Therefore, to simplify the standardization and implementation, we are fine without Scheme 2. |
| Qualcomm | There is no need to adopt two different schemes for HST-SFN enhancement. We think scheme-1 is sufficient and no further discussion is needed to support scheme-2. |
| LG | We support the proposal. Similar to Futurewei’s comment, we also think supporting of both schemes can provide flexibility in UE implementation perspective. Scheme 2 outperforms conventional SFN transmission as provided from companies. So we can study further about scheme 2 including possible enhancement aspects. |
| Intel | We support the proposal. Our initial evaluation results of scheme 2 with DM-RS overhead reduction (DM-RS ports from multiple TPR are transmitted in the same CDM group) show that overhead impact from multiple DM-RS ports transmission could be reduced without noticeable performance degradation. |
| Samsung | In our understanding, Scheme 2 is to provide better channel estimation performance by consuming higher DMRS overhead. So we are uncertain how Scheme 2 can be differentiated from Scheme 1 if its DM-RS overhead is reduced. Anyway, we are open to have further discussion. |
| Vivo | We have similar view with ZTE, Huawei, HiSilicon, and Qualcomm. In our understanding, there is no need to support scheme 2 for the following reasons:   * **Performance:** As shown in our simulation results [5], scheme 2 has no throughput gain than the other solutions for Rel-17 HST-SFN, due to more DMRS overhead. There is no need to specify a sub-optimal scheme for the same purpose. * **Complexity:** For simplicity of description**,** we assume that two DMRS ports are configured in scheme 2. That means a total of twice time-domain filtering would be operated for the LS channel estimation results from two DMRS ports, followed by composing two-part of channel estimation results to generate the equivalent channel for PDSCH. However, scheme 1 only needs once time-domain filtering with two Doppler shifts value estimated by two TRS. Moreover, UE complexity would be lower in the frequency shift pre-compensation scheme. Therefore, the UE complexity for scheme 2 seems higher than the other two schemes. |
| Lenovo/MotM | We support the FL proposal to further study Scheme 2. In our understanding, Scheme 2 covers other possible designs with PDSCH/PDCCH transmitted in SFN manner, whereas DMRS are transmitted in non-SFN manner. There are variants of Scheme 2 that may not require additional overhead compared with Scheme 1, which may need to be studied further. |
| Sony | Since the existing agreement(s) does not exclude Scheme 2 yet, it is up to each proponent to carry out further study the DMRS overhead issue of scheme 2. So in our view, we don’t need to have such a conclusion. |
| Apple | Fine with further study |
| Qualcomm | In our views, we don’t see any technical advantage to support SFN scheme 2 on top of supporting scheme 1. Based on the evaluations results from all the companies, there was NOT a single scenario where Scheme 2 has better performance than scheme 1. It is not justified to support such a scheme that has   * Inferoiro performance due to extra DMRS overhead   + Only for single Layer with same CDM group across TPRs, it has similar perfomrnace with scheme-1. Otherwise, scheme-1 outperforms. * Increase UE complexity due to double channel estimation complexity. * network Resource overhead (DM-RS). * Doesn’t scale to support PDDCH. * Not needed for Doppler shift pre-compensation technique.   As a group, I think we should focus our time and effort and discuss only the other related aspects of scheme-1 and the corresponding pre-compensation configuration. |
| CATT | With scheme 2, better channel estimation performance can be expected in the cost of DMRS overhead. So the throughput of scheme 2 is lower than that of scheme 1 from evaluation results of some companies. To keep the same DMRS overhead as in scheme 1, the benefit with channel estimation in schme 2 may not be notable. Actually, with scheme 1 and precompensation, even higher reliability can be achieved.  As raised by some companies, introducing scheme 2 brings flexibility to the system to some extent. On the other hand, the corresponding complexity in both standardization and implementation should be considered. Besides that, the applicability of scheme 2 to PDCCH enhancement is problematic.  Therefore, based on the discussion above, we don’t support to further study schme 2. |

Based on the feedback above the proposal is modified as follows.

**Proposal 1-6 (for conclusion):**

* *Alt 1: Further discuss the need of supporting scheme 2 in Rel-17 including possible DM-RS overhead reduction options*
* *Alt 2: Scheme 2 is not supported for Rel-17 HST-SFN scenario*

## NW based solutions

In RAN1#102-e meeting the following agreements were made regarding support of NW based solution for frequency offset compensation in HST-SFN scenario.

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| --- |
| **Agreement**  Study TRP-based frequency offset pre-compensation including the following aspects:   * Aspects related to indication of the carrier frequency determined based on the received TRS resource(s) in the 1st step   + **Option 1**: Implicit indication of the Doppler shift(s) using uplink signal(s) transmitted on the carrier frequency acquired in the 1st step     - Indication for QCL-like association of the resource(s) received in the 1st step with UL signal transmitted in the 2nd step     - Type of the uplink reference signals / physical channel used in the 2nd step, necessity of new configuration and corresponding signaling details   + **Option 2**: Explicit reporting of the Doppler shift(s) acquired in the 1st step using CSI framework     - FFS: Indication for QCL-like association of the resource(s) received in the 1st step with UL signal transmitted in the 2nd step     - CSI reporting aspects, configuration, quantization, signalling details, etc. * New QCL types/assumption for TRS with other RS (e.g., SS/PBCH), when TRS resource(s) is used as target RS in TCI state * New QCL types/assumptions for TRS with other RS (e.g., DM-RS), when TRS resource(s) is used as source RS in the TCI state * Target physical channels (e.g., PDSCH only or PDSCH/PDCCH) and reference signals that should be supported for pre-compensation * Signaling/procedural details on whether/how the pre-compensation is applied to target channels * Whether multiple sets of TRS and pre-compensation on TRS is needed in 3rd step.   Note: Other aspects/schemes are not precluded |

## Issue #2-1 (Support of TRP-based pre-compensation)

Regarding support of TRP-based pre-compensation schemes in Rel-17. Several companies expressed their views on this issue. Some companies have also provided LLS results comparing performance of TRP based pre-compensation with the baseline transmission scheme. Summary of the company’s preference is provided below:

**Issue#2-1:** Whether to support specification based TRP pre-compensations?

* TRP-based frequency offset pre-compensation is supported in Rel-17
  + Futurewei, Huawei, HiSilicon, vivo, ZTE, CATT, CMCC, Samsung, OPPO, Apple, ~~LGE,~~ NEC, Spreadtrum, Docomo, Sony
* TRP-based frequency offset pre-compensation is not supported in Rel-17
  + ~~LGE~~
* Further study support of TRP-based frequency offset pre-compensation in Rel-17
  + Nokia, Ericsson, Qualcomm, Lenovo/MotM, LGE(without spec impact)

Based on the company’s preference above, there is majority that prefers specification of TRP-based frequency offset compensation in Rel-17 for HST-SFN scenario. Therefore, the following proposal is made:

**Proposal 2-1:**

* *TRP-based pre-compensation is supported in Rel-17*
  + *FFS other details*

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| **Company** | **Comment** |
| CATT | In our opinion, TRP based pre-compensation for PDSCH and DMRS should be supported. However, TRP based pre-compensation for TRS is not needed. So, we suggest to revise the proposal as:   * *TRP-based pre-compensation for PDSCH/DMRS is supported in Rel-17*   + *FFS other details* |
| vivo | Support Proposal 2-1 |
| Huawei, HiSilicon | Support |
| Docomo | Support |
| Spreadtrum | Support |
| OPPO | Support. |
| Sony | Support Proposal 2-1 from FL. We could leave which channel/signal to be pre-compensated FFS. |
| ZTE | Support this proposal as the clear benefit can be observed based on our simulation and analysis in our tdoc |
| Samsung | Support |
| Ericsson | The gain showed with pre-compensation is at the same level comparing with DPS method in Rel-15, we are reluctant to support this scheme before we achieve a good understanding on the gain and benefit.  We’ve observed in our simulation, that the throughput at low SNR can be improved by applying 5 degree antenna direction downtilt towards the middle point. We’ve also observed using CDD in one TRP will improve the UE performance at the middle point, which doesn’t require changes in the specifications.  The simulation results/gain showed for pre-compensation can vary depending on following settings in the simulation, hence we would like to encourage companies to elaborate more about their simulation setups: **number of retransmissions**, the antenna tilt direction (towards middle point of the 2 TRP or other direction), extended CDL channel model with 4-TRP or 2-TRP, antenna pattern and precoding method. |
| LG | We think it is possible to support pre-compensation without spec impact. Spec impact can be decided based on discussion on the issue #2-2/3/4/5. So, whether to enhance spec or how to support TRP-based pre-compensation can be discussed further. |
| Nokia/NSB | Do not support.  We are not yet convinced that there is a substantial benefit with TRP-based pre-compensation on top of UE-based schemes. gNB’s pre-compensation per channel is not fully evaluated for its feasibility. |
| InterDigital | Do not support. Further evaluations is needed. |
| CMCC | Support.  Regarding the point raised by Ericsson that pre-compensation gain may vary depending on some simulation assumptions such as antenna tilt direction, pattern, etc., we think in the real network deployment, different situations may exist, we cannot make sure one solution shows very stable performance gain for all the cases. Based on the simulation result showed by majority companies, we think obvious gain can be observed with the typical assumptions we have agreed. |
| Lenovo/MotM | We believe further discussion is needed for frequency pre-compensation. For instance, the delay incurred by the 3 steps for pre-compensation should be considered in the analysis/evaluations, since it may further exacerbate the Doppler estimation due to outdated Doppler estimates |
| NEC | Share similar view with LG that pre-compensation can be supported without spec impact. |
| Apple | Fine with the FL proposal |
| Intel | Agree with FL proposal |
| Futurewei | Support the FL’s proposal |
| Qualcomm | We think that further study and analysis is needed before we decide on pre-compensation technique. The study should compare the gain of pre-compensation versus scheme 1 and other baseline schemes. Factors to be considered: accuracy of Doppler shift estimation or reporting, TRPs and UE residual CFO impact and time misalignment between TRPs. Also, due to the high-speed environment, there is mismatch between the time Doppler shift is estimated to the time where PDSCH is pre-compensated. All these factors/non-idealities should be further studied and evaluated.  As clearly stated in the WID “Evaluate and, if the benefit over Rel.16 HST enhancement baseline is demonstrated, specify QCL/QCL-like relation (including applicable type(s) and the associated requirement) between DL and UL signal by reusing the unified TCI framework”, we shouldn’t discuss the ignalng and QCL details of pre-compensation till a consensus is made on the gain and benefits of pre-compensation techniques. So, we think that it is too early to discuss issues 2-2 to 2-8. |
| FL | **Observations:**   * Some companies (5) proposed to further study performance of TRP based pre-compesation in the next RAN1 meetings. * There is clear majority of companies (14 with spec impact + 2 without spec impact) supporting FL proposal, i.e., support of TRP-based pre-compensation in Rel-17.   FL recommends to agree on proposal 2-1 |
| Ericsson | We will provide further simulation result to show that the CDD, DPS and pre-compensation, with increasing order of signalling/implementation complexity, are showing similar results. We also encourage other companies to do the same comparition.  As QC also mentioned, we would like to remind RAN1 about the WID description for 2d.2:  **Evaluate and, if the benefit over Rel.16 HST enhancement baseline is demonstrated, specify QCL/QCL-like relation(including applicable type(s) and the associated requirement) between DL and UL ignal by reusing the unified TCI framework.**  If the focus is not on evaluation to understand the benefit, but rush into agreement, we don’t feel that is the right direction to go. Why not spend a bit more time to understand if a method is really useful and beneficial? |
| OPPO | We are fine to perform further evaluation on gNB pre-compensation scheme in next meeting. |
| Nokia/NSB | We are also of the view that we don’t need to rush into an agreement and the frequency pre-compensation scheme should be further studied. There is still unclear point how accurately doppler shift estimation can be provided. Thus the study should include the feasibility of doppler shift estimation both in UE and gNB. |
| Lenovo/MotM | We agree with Ericsson, OPPO and Nokia. Beside evaluating the performance, we believe it is important to discuss whether pre-compensation would be studied as a basic process integrated with Scheme 1, or otherwise. |
|  |  |

## Issue #2-2 (Indication of of the carrier frequency for UL)

Regarding indication of the carrier frequency for UL transmission. Several companies expressed their views regarding this issue. Companies preferences are summarized below:

**Issue#2-2:** Indication of carrier frequency for TRP-based pre-compensation

* Option 1 (implicit) from RAN1#102-e agreement
  + Futurewei, Huawei, HiSilicon, vivo, ZTE, CATT, CMCC, Samsung, OPPO, Apple, LGE, NEC, Lenovo/MotM, Spreadtrum, Qualcomm
* Option 2 (explicit) from RAN1#102-e agreement
  + Apple, Sony, Ericsson (if pre-compensation is supported), Qualcomm
* Further study
  + Nokia

Based on majority view, the following proposal is made:

**Proposal 2-2:**

* *Implicit approach (i.e., Option 1 from RAN1#102-e agreement) is used for indication of carrier frequency*
  + *FFS whether or not it has any spec impact and details of possible specification support*

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| **Company** | **Comment** |
| CATT | Support this proposal. |
| Vivo | Support Proposal 2-2 |
| Huawei, HiSilicon | Support |
| Spreadtrum | Support |
| OPPO | Support |
| Sony | In reality, there could be frequency shift at UE side due to impairment of oscillator. If only implicit method is adopted, NW will see 2 times of Doppler shift + 1 time of frequency shift at UE side, thereby NW may not be able to accurately estimate and then pre-compensate the Doppler shift. So we suggest to additionally support Option 2. |
| ZTE | Support |
| Samsung | Support |
| Nokia/NSB | If it is agreed to support frequency pre-compensation, we slightly prefer option 1, but need more evaluation of accuracy of the frequency offset estimation in UL. |
| InterDigital | We propose the following,   * *Explicit approach (i.e., Option 2 from RAN1#102-e agreement) is not supported for indication of carrier frequency* * *FFS whether the implicit approach (i.e., Option 1 from RAN1#102-e agreement) is needed* |
| CMCC | support |
| Lenovo/MotM | Support the FL proposal |
| Apple | It depends on the design of option 1, i.e., the SRS design, SRS is not designed for the accurate T/F tracking, i.e., similar as the TRS time domain structure. We would think that TRS can provide better T/F error estimation especially for high speed scenarios. |
| Intel | Support FL proposal |
| Futurewei | Support the FL’s proposal |
| FL | **Observations:**   * There is clear majority supporting FL proposal   FL recommends to agree on proposal 2-2 |
| Nokia/NSB | This proposal is premature, pending agreement on the support of frequency pre-compensation. |
| Lenovo/MotM | We support the FL proposal, however we agree with Nokia it should be conditioned on supporting the frequency pre-compensation scheme. |

## Issue #2-3 (QCL-like association between DL and UL RS)

Regarding support of QCL-like association between DL and UL RS, e.g. for carrier frequency indication in UL. Several companies expressed their views whether it requires specification support or can be up to UE implementation. Companies views on this issue are summarized below:

**Issue#2-3:** Whether to support QCL-like association between DL and UL RS?

* QCL-like association of the resource(s) received in the 1st step with UL signal transmitted in the 2nd step is supported by specification
  + Futurewei, Huawei, HiSilicon, InterDigital, CMCC, OPPO, Sony, Nokia (if supported), Intel, Spreadtrum, Qualcomm
* QCL-like association of the resource(s) received in the 1st step with UL signal transmitted in the 2nd step is supported by implementation without specification impact
  + vivo, CATT, Samsung, LGE, NEC

Based on majority view, the following proposal is made

**Proposal 2-3:**

* *QCL-like association of the resource(s) received in the 1st step with UL signal transmitted in the 2nd step is supported by specification*
  + *FFS detailed solution*

|  |  |
| --- | --- |
| **Company** | **Comment** |
| CATT | Whether specify the QCL-like association or not should be discussed later. The conclusion should be made based on the performance comparison of the scheme that UE determines the carrier frequency of UL signal transmission in the 2nd step based on an indicated TRS and the scheme that UE determines the carrier frequency of UL signal in the 2nd step according to its implementation. |
| Vivo | Don’t agree with Proposal 2-3. We observed that the uplink frequency doesn’t affect the pre-compensation results. Pre-compensation can still work well by implementation without QCL-like association between UL signals and TRS. |
| Huawei, HiSilicon | Support.  With frequency pre-compensation, only one of TRS ports is with the same Doppler related large scale channel information with the DMRS. So, the QCL-like information need to be specified to indicate which the anchor frequency is for both DL and UL. |
| OPPO | Further evaluation is needed for the association. |
| Sony | Support above proposal from FL. |
| ZTE | The wording of this proposal is not clear for us. QCL-like configuration for UL signal, e.g. SRS may not be the best solution. That’s because unified TCI discussed in 8.1 may not always include DL signal as QCL reference. For example, SRS may be the QCL source for a DL or UL target signal.  In order to inform UE the carrier frequency for SRS, perhaps pathloss-RS can be a good choice.  So our proposal is to agree association DL and UL RS first, then discuss how to indicate the DL RS.  **Proposal 2-3:**   * *Support association between DL RS and UL signal for carrier frequency indication in UL in the 2nd step*   + *FFS the DL RS is configured in TCI ( i.e. QCL-like configuration for UL signal) or in pathloss configuration or in others* |
| Samsung | Not support the proposal. If it’s possible to solve the issue without specification impact, no change in the specification is a default way to go. We don’t see the necessity why the association between DL and UL RS is necessary for Doppler pre-compensation. In Rel-16 HST, UL transmission works without such association and pre-compensation can be done by implementation. |
| LG | We have similar view with vivo/Samsung. Before making the decision, we think the issue should be clarified. |
| Nokia/NSB | Do not support.  Also, the purpose of QCL-like association first needs to be clarified. If it is only for carrier frequency indication, some companies have shown that the frequency pre-compensation scheme does not require the carrier frequency of the UL RS to correspond to the received carrier frequency of TRS received from either of the TRPs. |
| Ericsson | We think it is premature to discuss this level of details in this meeting. |
| CMCC | Support it in principle. This proposal related to Issue 2-4, if Variant A is agreed in issue 2-4, we see two alternatives for this issue.   * **Alt 1:** **Network explicitly indicates UE the QCL-like association of the TRS received in the 1st step with UL signal transmitted in the 2nd step.** * **Alt 2: If two TRSs and corresponding QCL-Types (i.e., QCL-TypeA and QCL-TypeE) for DMRS are indicated to the UE, UE will automatically use the TRS corresponding to QCL-TypeA to determine the modulated UL carrier frequency.** |
| Lenovo/MotM | We support the FL proposal. More specifically, using the same spatial filter for UL/DL RSs by the UE should be specified, similar to UE behavior defined for SRS spatial relation info defined in Rel. 15/16 |
| NEC | Not support. We share similar view with vivo/Samsung/LG that this can be supported by implementation without spec impact. |
| Apple | Right now, gNB can configure the QCL source for SRS transmission. We are wondering what is the intention of this FL proposal. |
| Intel | Support FL proposal |
| Futurewei | Support the FL’s proposal |
| FL | **Observations:**   * Majority of companies support FL proposal 2-3, but noticeable number of companies think further study is required on necessity of specification-based association or mention spec based association is not needed   FL recommends to discuss this issue further after agreement on support of TRP-based pre-compensation is made. |
| Lenovo/MotM | We support the FL proposal, also it should be clarified the discussion of this proposal is conditioned on the support of the frequency pre-compensation scheme |

## Issue #2-4 (QCL types/assumptions when TRS is source)

Regarding new QCL types/assumption for TRS with other RS (e.g., DM-RS), when TRS resource(s) is used as source RS in the TCI state. The following variants of QCL types/assumption were proposed by companies.

**Issue#2-4:** Possible variants of new QCL types/assumption for TRS for specification in Rel-17

* **Variant A**: 1st TRS is used for estimation of {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA) and the 2nd TRS is used for estimation of {*average delay, delay spread*} (i.e., new QCL-Type-TBD)
  + CMCC, Sony, Huawei, HiSilicon, ZTE, CMCC,
* **Variant B**: 1st TRS is used for estimation of {*average delay, delay spread*} (i.e., QCL-Type-TBD1) and the 2nd TRS for estimation of {*Doppler shift, Doppler spread*} (i.e., QCL-Type-TBD2)
  + CATT, Intel, Ericsson (? And if supported)
* **Variant C**: 1st TRS is used for estimation of {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA) and the 2nd TRS is used for estimation of {*delay spread*} (i.e. new QCL-Type-TBD)
  + vivo
* **Variant D**: Specify that for TCI state related to the 2nd TRS, i.e., UE ignores {*Doppler shift, Doppler spread*} in the (i.e., QCL-TypeA) of TCI state, without defining new QCL types
  + vivo, Sony,OPPO

Based on the company’s preference above, the following proposal can be made:

**Proposal 2-4:**

* *New QCL types/assumption for TRS with DM-RS (when TRS resource(s) is used as source RS in the TCI state) is supported in Rel-17*
  + *FFS which variant or combination of variants should be specified in Rel-17*

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| --- | --- |
| **Company** | **Comment** |
| CATT | Either variant A or B can be supported. |
| Vivo | We are fine with both **Variant C** and **Variant D**.  **Variant C:** we think providing {delay spread} based on the 2nd TRS is enough, since the DL timing should be adjusted based on the 1st TRS, like Doppler shift.  From our view, how to estimate the average delay with two TRS is depend on UE implementation.   * The first way is that the 1st and 2nd TRS estimate the average delay separately. In this case, just referring to one of the two average delay values is enough. That means the 2nd TRS’s average delay is not useful. If both the 1st and 2nd TRS provide {*average delay*}, UE would be confused about which average delay value should be referred to. * The second way is using the 1st and 2nd TRS to estimate the average delay together based on their composed channel. In this case, we would get only one average delay value. However, due to the path delays from different TRPs, this calculated average value by the composed channel of the 1st and 2nd TRS is less accurate than the average value calculated by the channel of the 1st TRS as shown below.     **Variant D:** Instead of defining a new QCL-type, Variant D is also a feasible way to solve the problem. In Variant D, we can specify default behavior for UE to ignore Doppler parameters in the TCI state (i.e., QCL-TypeA) related to the 2nd TRS. This method can achieve the same target as Variant C. |
| Huawei, HiSilicon | Support the proposal. |
| OPPO | We support Variant D which has minimized specification impact and the same function as other options. |
| Sony | Either variant A or D is fine to us and we slightly prefer variant D.  Moreover, as for variant D, we only need to specify UE’s behavior rather than creating a new QCL-TypeD which only includes existing large-scale channel properties in time domain. |
| ZTE | **Support Variant D** suggested by vivo.  New QCL types are not needed from our view since they will change RRC configuration and cause signaling overhead. Further, if we introduce new QCL type, e.g. type E in a TCI state configuration, the TCI state will not be able to be shared to other target signal, such as CSI-RS. Then the total number of TCI states should be increased.  From our view, once UE can identify the PDSCH transmission is based on frequency pre-compensation even QCL-Type A is indicated, UE can just ignore some QCL estimations from the QCL-TypeA, e.g. UE ignores Doppler shift and Doppler spread, and just leverages average delay and delay spread from the QCL-TypeA. Then, there is no RRC impact. The only spec impact may be just one sentence for UE assumption.  Thus, our suggestion is  **Proposal 2-4:**   * *New QCL assumption for TRS with DM-RS (when TRS resource(s) is used as source RS in the TCI state) is supported in Rel-17*   + *FFS which variant or combination of variants should be specified in Rel-17*   + *FFS whether new QCL type is needed or not.* |
| Samsung | We think new QCL types or assumptions can be applicable to other RSs in addition to DM-RS. The other RS can be TRS/CSI-RS for CSI/etc. Suggest to generalize the wording as follows:   * *New QCL types/assumption for TRS with other RS (when TRS resource(s) is used as source RS in the TCI state) is supported in Rel-17*   + *FFS which variant or combination of variants should be specified in Rel-17*   + *FFS types of the other RS* |
| LG | We think this issue is related to issue #2-7. So, it would be better to discuss issue #2-7 first. |
| Nokia/NSB | We cannot agree to this proposal since it does not specify the details of the new QCL type. Also, we first need to agree on all the steps of the frequency pre-compensation scheme before we can discuss whether a new QCL type is needed to support the scheme. |
| Ericsson | We think it is premature to discuss this level of details in this meeting. |
| InterDigital | Support FL proposal. |
| CMCC | Either Variant A or D is fine |
| Lenovo/MotM | Support Variant A (if frequency pre-compensation is supported) |
| Apple | Need more discussion |
| Intel | We should consider scenario where one TRS is transmitted in SFN manner for backwards compatibility with old Ues. In this case Variant B should be supported, where SFN-ed TRS can be used to derive delay related parameters and TRS from the reference TRP can be used to derive Doppler related parameters |
| Futurewei | Support the FL’s proposal |
| FL | **Observations**:   * If TRP based pre-compnesation is supported, majority of the companies prefer to down-select from the vartiants A, B, C, D in the next e-meeting.   FL recommends to agree on FL proposal + Variants A, B, C, D for further study in the next e-meeting. |
| Nokia/NSB | Pending futher agreement on further details on the support of a frequency pre-compensation scheme, it is premature to agree on whether new QCL types/assumptions need to be supported. |
| Lenovo/MotM | Support the FL proposal |

## Issue #2-5 (QCL types when TRS is target)

Regarding new QCL types/assumption for TRS with other RS (e.g., SS/PBCH), when TRS resource(s) is used as target RS in TCI state. Two companies proposed to introduce new QCL type to account possibly different Doppler shift and Doppler spread characteristics between source RS and the target RS [9][21].

**Issue#2-5:** Support of new QCL type (e.g., loose Doppler shift relationship) between the TRS (including aperiodic TRS) and source RS (e.g., SSB or periodic TRS)

**Proposal 2-5:**

* *Companies to provide their views on necessity of the corresponding enhancement*

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| **Company** | **Comment** |
| Huawei, HiSilicon | Not support. TRS is the main resource for QCL assumptions, while the QCL link from SSB to TRS is a rough information. The main information of Doppler and Delay is from TRS to DMRS, we do not see the necessary to enhance the QCL in the link from SSB to TRS.  We also don’t think compensation on TRS is feasible considering overhead. |
| ZTE | Not needed. |
| Samsung | Support the proposal.  Current specification allows TRS to be a QCL target of another TRS, and there’s no reason to exclude such use case for the new QCL type. |
| LG | We think this issue is related to issue #2-7. So, it would be better to discuss issue #2-7 first. |
| Ericsson | We think it is premature to discuss this level of details in this meeting. |
| InterDigital | Support FL proposal, details to be discussed later. |
| CMCC | It is not necessary |
| Lenovo/MotM | Agree with LG, should decide on issue #2-7 first |
| Intel | Support for further study on details in the next meeting. |
| Futurewei | We think this might be useful for the 2nd TRS if introduced. The 2nd TRS has a different Doppler than its source SSB1 and SSB2. It is better to discuss this. |
| FL | **Observations**:   * There is no majority to support new QCL types when TRS is used as target RS in this e-meeting * Further discussion is needed |

## Issue #2-6 (Target physical channels)

Regarding target downlink physical channels that can be used with TRP-based pre-compensation. Some companies provided their preference on this issue between the following options – PDSCH only or PDSCH + PDCCH. Summary of the company’s views is provided below:

**Issue#2-6:** Physical channels and reference signal that should be supported for TRP-based pre-compensation

* PDSCH only
  + CMCC (?)
* PDCCH + PDSCH
  + Futurewei, vivo, Samsung, ~~LGE~~, NEC, Intel, Docomo, Sony, CMCC
* Further study
  + OPPO

**Proposal 2-6:**

* *TRP-based pre-compensation is supported for both PDCCH and PDSCH*

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| --- | --- |
| **Company** | **Comment** |
| CATT | TRP-based pre-compensation for PDCCH+PDSCH can be considered. |
| Vivo | Support Proposal 2-6 |
| Huawei, HiSilicon | PDCCH with M-TRP is under discussing in 8.1.2.1, it should be treated later. |
| DOCOMO | Support |
| OPPO | It depends on whether scheme 1 is supported for PDCCH. We suggest to discuss it later. |
| Sony | Support above proposal from FL. The reason lies in the fact that if PDCCH (without pre-compensation in frequency domain) cannot be decoded by UE, the scheduled PDSCH (even though with pre-compensation in frequency domain) has no chance to be successfully decoded by UE. |
| ZTE | Support |
| Samsung | Support. |
| Nokia/NSB | Do not support. It is not yet clear whether there is a substantial benefit from supporting frequency pre-compensation for PDCCH. Operation of PDCCH reception with/without pre-compensation should be clarified. |
| Ericsson | We think whether to support both PDCCH and PDSCH should be based on evaluations. |
| InterDigital | Support FL proposal. |
| CMCC | Fine with FL proposal |
| Lenovo/MotM | Agree with Huawei. Only discuss after 8.1.2.1 makes progress on mTRP PDCCH |
| Apple | There are PDCCH that is targeted for all the UE in the system, how can we ensure all the PDCCH can be enhanced? |
| Intel | Support. PDCCH blocking is a big issue in HST due to high number of Ues. Some PDCCH can take advantage from TRP based pre-compensation so smaller AL can be supported for the UE. |
| Futurewei | Support the FL’s proposal |
| FL | **Observations:**   * There is majority that prefers supporting TRP based pre-compensation for both PDSCH and PDCCH * Several companies indicated overlap with the discussion in agenda item 8.1.2.1 (mTRP for PDCCH), but it is not clear whether it considers TRP pre-compensation scheme and HST-SFN scenario. |
| OPPO | If we support TRP based pre-compensation for PDSCH, the required additional standardization effort to further support it for PDCCH is minimal. We can make the decision after we have clear solution on PDSCH. |
| Lenovo/MotM | We believe this proposal is strongly related to that of Proposal 1.2, and whether the frequency pre-compensation scheme will be integrated with Scheme 1. We suggest deferring this proposal until the pre-compensation scheme is supported **and** it is clarified how it is incorporated with Scheme 1 |

## Issue #2-7 (2nd set TRS with pre-compensation)

Regarding support of pre-compensated TRS in 3rd step. The following views were provided by companies.

**Issue#2-7**: Whether to support frequency offset pre-compensation on TRS in 3rd step

* Supported: Futurewei, Samsung, Ericsson (?), LG
* Not supported: vivo, Intel, CATT, OPPO, Nokia, Huawei, HiSilicon, Sony, CMCC

Based on the views above the following proposal is made

**Proposal 2-7:**

* *Further study necessity and specification impact of supporting frequency offset pre-compensation on TRS*

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| **Company** | **Comment** |
| CATT | UE-specific frequency offset pre-compensation on TRS requires large overhead. Furthermore, according to our simulation results, the benefits of UE-specific frequency offset pre-compensation on TRS is limited compared to TRP-specific TRS without frequency offset pre-compensation. Hence, frequency offset pre-compensation on TRS is not needed. |
| Vivo | We prefer no frequency offset pre-compensation on TRS in 3rd step, considering the overhead of TRS. |
| Huawei, HiSilicon | Not support for TRS pre-compensation at this stage. |
| Spreadtrum | Not support for the reason of the large overhead. |
| OPPO | We agree with CATT, vivo, Spreadtrum and Huawei. |
| Sony | Considering DL RS overhead, we don’t see strong benefits to have frequency-domain pre-compensated TRS as well. |
| ZTE | We think there is no spec impact for this issue. But we are fine with the proposal |
| Samsung | We prefer to support pre-compensated TRS in 3rd step.  When pre-compensation is done by implementation in Rel-16, gNB would transmit pre-compensated TRS and make QCL association with it and DM-RS. There’s no reason to block such use case for Rel-17 only. |
| LG | We have similar view with Samsung. In this case, the current QCL type can be used for TRP based pre-compensation scheme. Regarding RS overhead for pre-compensated TRS, it can be reduced by supporting of the same pre-compensated TRS for group of Ues. |
| Nokia/NSB | Need further clarification about overall procesures. If pre-compensated TRS is supported. We don’t see any specification impact other than overhead increase with additional TRS transmission. Since |
| Ericsson | We think the decision should be based on evaluations. It is premature to discuss this level of details in this meeting. |
| InterDigital | Do not support for TRS pre-compensation at this stage. |
| CMCC | Not support, otherwise the overhead of TRS will be too large since different Ues require different pre-compensations. |
| Lenovo/MotM | Not support |
| NEC | Not support. |
| Apple | Fine with FL proposal |
| Intel | Further study is required on performance benefits comparing to TRP specific TRS transmission. |
| Futurewei | Agree with Samsung |
| FL | **Observations**:   * Majority prefers not to support TRS pre-compensation for TRS transmitted in the 3-rd step, due to large TRS overhead * Several companies mentioned that this scenario of TRS transmission should not be precluded * It seems there is no specific proposal that can be drawn for this issue in this e-meeting. It is proposed to continue discussion on this issue as in the FL proposal |

## Issue #2-8 (Configuration of TRP pre-compensation)

Similar to scheme 1/2, the issue of configuration of TRP pre-compensation scheme and dynamic switching with other schemes should be addressed.

**Issue#2-8:** How to support configuration of TRP pre-compensation including dynamic switching with other schemes?

**Proposal 2-8:**

* *Companies to provide their views on this issue*

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| **Company** | **Comment** |
| CATT | This issue can be discussed with lower priority. |
| Vivo | It can be discussed after determining the final solution for Rel-17 HST-SFN. |
| Huawei, HiSilicon | A little early to discuss this issue, it dependents on schemes discussion. |
| Docomo | This should be discussed later. |
| OPPO | Discuss it later. |
| Sony | Agree with CATT on the thinking of priority. |
| ZTE | We are fine to discuss it later.  RRC signaling is needed firstly. Dynamic switching between SFN and Rel-16 TDM/FDM is unnecessary. So once RRC signaling enables SFN, two TCI states are indicated by TCI codepoint in DCI, and the DMRS ports are within the same CDM group, UE can determine the transmission is SFN. |
| Samsung | Prefer to discuss after the basic design of pre-compensation is stabilized. |
| LG | We also think signaling details can be discussed after decision on schemes. |
| Nokia/NSB | Should be discussed later. |
| Ericsson | This level of details should be discussed in later meetings. |
| InterDigital | To be discussed later. |
| CMCC | Discuss later |
| Lenovo/MotM | We believe this should be addressed after decision on adopting Scheme1, Scheme 2 and/or Frequency pre-compensation |
| Apple | If there is need for dynamic switching, we prefer clean solution, i.e., either rely on RRC or MAC-CE. No combo solution |
| Intel | RRC may be sufficient but open to dynamic switching if benefits are clear. |
| Futurewei | Can discuss later |
| FL | Further feedback will be collected after progress is made for TRP-based pre-compensation |

## Issue #3-1 (Refinements to EVM)

Two companies provided discussion on EVM refinement for HST-SFN evaluations [16][17] with the following proposals:

* A 4-tap extended CDL channel model is necessary to capture the potential inter-symbol interference for the agreed TRP layout and SCS=30kHz
* SNR values of {8, 12, 16, 20} dB are not applicable to CDL channel model and should be recommended only for 4-tap channel model
* Three antenna panels at the UE should be used for FR2 evaluation. Consider evaluation of different antenna array orientation options in the azimuth domain
  + Random orientation with uniform distribution
  + Pre-determined with bore-sight direction of {300, 1500, -900} relative to train direction

**Proposal 3-1:**

* *Companies to provide their views on the above proposals.*

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| **Company** | **Comment** |
| vivo | * We are ok with the 4-tap extended CDL channel model, but it seems the RAN4 4-tap channel model agreed in #102e meeting can be used to evaluate the potential inter-symbol interference. We can use it for evaluation considering the workload of simulation. * Agree with SNR values of {8, 12, 16, 20} dB only for RAN4 4-tap channel model. * We are ok with three antenna panels at the UE for FR2. * Small delay CDD can be considered in the simulation for performance enhancement. |
| Huawei, HiSilicon | We need to avoid the discussion of EVM again, while current EVM assumptions are aligned by companies and no essential issues. |
| ZTE | No need to discuss this |
| Samsung | For FR2 evaluation, commonly considered number on UE panels is one or two. We don’t find necessity of having three antenna panels for HST evaluation only. |
| Ericsson | We think it is essential to clarify and align evaluation assumptions. Otherwise, how can we believe/compare results if different assumptions are used by different companies? |
| Qualcomm | * Support SNR values of {8, 12, 16, 20} dB only for RAN4 4-tap channel model. * Also, we should discuss what SNR values for the extended CDL channel model.   Note: The discussion of SNR values may not be a major issue if MCS link-adaptation is enabled in the simulation. |
| FL | **Observations:**   * There is not enough interest to make amendments to EVM * Further justification is needed to make the corresponding changes to EVM |

## Issue #4-1 (Other non-categorized proposals)

Some aspects proposed by companies doesn’t have specific categorization and provided below for other company’s reference. It is proposed to consider the following enhancements in the next RAN1 meetings.

* *Study zone-based configuration for TCI/QCL information to mitigate potential high signaling overhead.*
* *Support new QCL information indicating opposite polarity of Doppler shift between different transmissions.*
* *Support variable-rate TRS transmission for HST deployment scenario.*
* *Support distributed CSI-RS and CSI feedback operation*
* *TCI states configured in non-serving cell(s) with PCI either explicitly configured or implicitly associated*
* *Support of unified TCI state in DCI to trigger SP/AP-TRS followed by SP/AP-SRS*
* *Introduce a UE assisted DMRS adaptation for DL, in which UE provides an indication of the most convenient DMRS configuration option per estimated channel and SNR conditions*
* *Introduce a new mechanism for dynamic DMRS configuration signaling to enable DMRS adaptation.*
* *Introduce new SRS pattern for UL Doppler estimation purpose, comprised of two non-consecutive SRS symbol repetition with configurable time gap between the symbols*
* *Support transmitting DMRS REs for one antenna port in FDM fashion from both TRPs*

**Proposal 4-1:**

* *Consider the above enhancements in the future RAN1 meetings*

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| **Company** | **Comment** |
| ZTE | No need to discuss |
| InterDigital | * + - * Need to discuss zone-based or positioning-assisted approach for TCI/QCL update, otherwise the required signaling overhead would be very high.       * Also, adaptive RS transmission, e.g., TRS, DMRS are needed to provide a robust performance for HST. |
| Lenovo/MotM | Support transmitting DMRS REs for one antenna port are transmitted in FDM fashion from both TRPs. Advantages:  - Reasonable tradeoff between performance/overhead of Schemes 1,2  - No pre-compensation necessary |
| Qualcomm | * + - * Support the study of UE assisted DMRS adaptation in DL with DMRS reporting and dynamic DMRS signaling for HST-SFN deployments.   Support the study of SRS patterns to enable enhanced and more precise UL Doppler estimation. |
|  |  |

## Further discussion on HST-SFN enhancements

The following agreements on support of HST-SFN enahncements were made in GTW session:

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| **Agreement**  Support at least the following configuration for HST scenario in Rel-17   * The same DMRS port(s) can associate with multiple QCL/TCI states   + Note: DMRS and [PDCCH]/PDSCH from different TRPs are transmitted in SFN manner   + FFS other details   **Agreement**  At most two QCL/TCI states are supported for HST scenario in Rel-17   * FFS: Whether to support more than two QCL/TCI states for FR2 * FFS configuration/signalling details of the QCL/TCI states * Note: DMRS and [PDCCH]/PDSCH from different TRPs are transmitted in SFN manner |

## Issue #5-1 (QCL types/assumptions for same DMRS port(s))

Based on the agreement above, it should be further discussed which QCL types/assumption can be used when TRS is used as source RS for the same DM-RS port(s).

**Proposal 5-1:**

* When the same DMRS port(s) are associated with two QCL/TCI states containing TRS as source reference signal
* **Variant A**: One of QCL/TCI state can be associated with {*average delay, delay spread*} (i.e., new QCL-Type-TBD) and another QCL/TCI states can be associated with {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA)
  + *Supported by:*
* **Variant B**: One of the QCL/TCI state can be associated with {*average delay, delay spread*} (i.e., new QCL-Type-TBD1) and another QCL/TCI state with {*Doppler shift, Doppler spread*} (i.e., QCL-Type-TBD2)
  + *Supported by:*
* **Variant C**: One of the QCL/TCI state can be associated with {*delay spread*} (i.e. new QCL-Type-TBD) and another QCL/TCI states can be associated with {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA)
  + *Supported by:*
* **Variant D**: Both QCL/TCI states can be associated with {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA), but for one QCL/TCI states, UE ignores {*Doppler shift, Doppler spread*}
  + *Supported by:* ZTE
* **Variant E**: Both QCL/TCI states can be associated with {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA)
  + *Supported by:*

Companies to provide feedback on the wording of the proposal 5-1 as well as indicate their preference for the specific variant or combination of variants to be supported for Rel-17 HST-SFN scenario.

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| **Company** | **Comment** |
| ZTE | Support Variant D.  Variant A,B,C need to change RRC structure for TCI state. In such case, the new TCI states including new QCL type cannot be shared for target signals other than PDSCH, e.g. CSI-RS which should use legacy QCL type. Noted that TCI state pool configured by RRC is shared for all DL signals. Thus, the total number of TCI states should be increased if new type of TCI state is introduced by Variant A,B or C. |
| Huawei, HiSilicon | Support A.  A is relative a clean solution. With pre-compensation, the PDSCH is associated with one TRS, while the other TRS provided QCL information with {average delay and delay spread}. |
| Ericsson | The agreements are made under Scheme 1. There’s no consensus on supporting other schemes, which means Variant A-D shall not be discussed until further agreement on supporting other schemes being made.  We would like to make following adjustment to the proposal:  When the same DMRS port(s) are associated with two ~~QCL/~~TCI states containing TRS as source reference signal   * Both ~~QCL/~~TCI states are associated with {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA)   + Note: DMRS and [PDCCH]/PDSCH from different TRPs are transmitted in SFN manner |
| Futurewei | We prefer A, and may also accept E depending on the scenarios.  So for one DMRS port, there are 2 source TRSs. An example is:   * + - * TRS1: channel 1 has cluster 1 with average delay 1, delay spread 1, Doppler spread 1, and Doppler shift 1.       * TRS2: channel 2 has cluster 2 with average delay 2, delay spread 2, Doppler spread 2, and Doppler shift 2.   Clearly, the DMRS port sees both clusters 1 and 2, so at least average delay and delay spread need to be included in both QCL/TCI states. Furthermore, if the channels have different Doppler, then either one channel is used for deriving the Doppler or both channels are used (with some further processing). If the channels have same Doppler, then either one channel can be used or both can be used. |
| Qualcomm | We think the selection of varriants A to D should be discussed later when network-based solution (i.e. Doppler shift pre-compensation) is adopted. Right now, only scheme-1 is supported, therefore variant E should be only supported at the moment.   * Suggest the wording below:   Each TCI state is associated with {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA) + optional { Spatial Rx parameter} (i.e., QCL-TypeD)   * Note: DMRS and [PDCCH]/PDSCH from different TRPs are transmitted in SFN manner |
| LG | We have the same view with QC. First, variant E revised by QC should be supported considering the case when network does not conduct Doppler precompensation. In addition, before we make decision on variants A to D, it should be discussed first whether Doppler precompensation of DMRS and/or TRS is applied. If both DMRS and TRS are precompensated or neither, we don’t need variant A to D. |
| Samsung | Fine with either A or D. It seems that A and D are effectively the same, just with different expressions. Suggest to merge A and D, and then further discuss how to assume or indicate UE to use {*Doppler shift, Doppler spread*} for the second TCI state.   * **Variant A’**: One of QCL/TCI state can be associated with {*average delay, delay spread*} and another QCL/TCI states can be associated with {*average delay, delay spread, Doppler shift, Doppler spread*}   + - *FFS: Indication method to apply QCL for {average delay, delay spread}, e.g., via new QCL-type, or reuse existing QCL-type while UE to ignore certain QCL properties* |
| Intel | We support variants B and E.  Regarding variant B. In our view HST SFN deployment should support SFN-ed transmission of TRS for backwards compatibility with Rel-16 UEs. In this case such TRS can be used to estimation of the delay related parameters { *average delay, delay spread }*. Then the remaining QCL parameters { *Doppler shift, Doppler spread* } can be derived from TRP based transmission of TRS.  Regarding variant E. It should be supported for scheme 1. |
| Qualcomm | Support the FL proposal. Couple of comments:   * A typo in variant B where the 2nd TCI state should be QCL typeB not typeC   **Variant B**: One of the QCL/TCI state can be associated with {*average delay, delay spread*} ~~(i.e., new QCL-Type-TBD1)~~ and another QCL/TCI state with {*Doppler shift, Doppler spread*} (i.e., 'QCL-TypeB')   * Reply to InterDigital: In our underatanding, the UE autonomsly will be able to figure out that the Doppler shift/spread from TRS1 is different from TRS2. Not sure the advntages of variant A’. |
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Given that RAN1 is unlikely can down select supported options in this meeting, it is proposed to take all alternatives for further study.

**Updated proposal 5-1:**

* When the same DMRS port(s) are associated with two QCL/TCI states containing TRS as source reference signal, at least one variant is supported for Rel-17 HST-SFN scenario
* **Variant A**: One of QCL/TCI state can be associated with {*average delay, delay spread*} ~~(i.e., new QCL-Type-TBD)~~ and another QCL/TCI states can be associated with {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA)
* **Variant B**: One of the QCL/TCI state can be associated with {*average delay, delay spread*} ~~(i.e., new QCL-Type-TBD1)~~ and another QCL/TCI state with {*Doppler shift, Doppler spread*} (i.e., ‘QCL-TypeB’)
* **Variant C**: One of the QCL/TCI state can be associated with {*delay spread*} ~~(i.e. new QCL-Type-TBD)~~ and another QCL/TCI states can be associated with {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA)
* **~~Variant D~~**~~: Both QCL/TCI states can be associated with {~~*~~average delay, delay spread, Doppler shift, Doppler spread~~*~~} (i.e., QCL-TypeA), but for one QCL/TCI states, UE ignores {~~*~~Doppler shift, Doppler spread~~*~~}~~
* **Variant E**: Both QCL/TCI states can be associated with {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA)
* FFS: Indication method to apply QCL, e.g., via new QCL-type, or reuse existing QCL-type while UE to ignore certain QCL properties
* Note 1: Each TCI state in the above variants may be additionally associated with {Spatial Rx parameter} (i.e., QCL-TypeD)
* Note 2: Companies are encouraged to provide evaluation results for the above variants based on agreed EVM from RAN1#102e meeting

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| **Company** | **Comment** |
| vivo | Fine with Updated proposal 5-1. We want to remind colleagues that the Updated proposal 1-1 which has been agreed upon online doesn’t mean scheme1 is already supported. Only after **Variant E** is agreed, then we can say scheme 1 is supported in Rel-17. Moreover, it’s easy to observe the only difference between **Variant A** and **Variant C** is whether the TCI state should provide {Average delay} or not. As we have analyzed in section 2.2.4, it’s inappropriate to provide {Average delay} in both TCI states, which would cause ambiguity and less accuracy. Therefore, we suggest further analyzing the UE implementation, especially average delay estimation based on two TRS in the next e-meeting. |
| Lenovo/MotM | We support the updated FL proposal |
| Sony | We are okay with either Variant A or **Variant D**. In our view, **Variant D** can be a very simple solution which allows UE to ignore some parts (frequency domain) of QCL information. But after modification, it seems **Variant D** has been removed and demoted as an “FFS”. We think all Variants can be considered at current stage and to be narrowed down in next meeting.  Additionally, as Qaulcomm mentioned, which variant RAN1 should select highly depends on the Doppler frequency pre-compensation scheme at NW side. So we would suggest to discuss the frequency pre-compenstation scheme first. |
| Apple | We are fine to leave to the next meeting.  Variant E is the preferred one for us. |
| InterDigital | Comment 1: In the main bullet, need to clarify that there are different TRSs   * When the same DMRS port(s) are associated with two QCL/TCI states containing different TRSs as source reference signals, at least one variant is supported for Rel-17 HST-SFN scenario   Comment 2:   * + - * We don’t understand Variant B, and not quite sure if it makes sense.       * Variants A, C and D seem to say a same thing that Doppler information cannot be derived from one of the TCI states.       * Use of Variant E may be confusing for receiver processing as it doesn’t indicate the opposite perceived Doppler by the receiver.       * For down-selection, we would like to include a modified version of Variant A, namely A`:   **Variant A`**: One of QCL/TCI state can be associated with {*average delay, delay spread, Doppler shift****1****, Doppler spread****1*** }, and another QCL/TCI states can be associated with {*average delay, delay spread, Doppler shift****2****, Doppler spread****2***} (i.e., QCL-TypeA) |
| Samsung | Fine with the updated proposal.  Besides, we want to clarify that these variants are considered for pre-compensation schemes only, as it was originally discussed in issue #2-4. |
| OPPO | We are fine to discuss these alternatives.  One comment to InterDigital: What is the difference between Doppler shift1 and Doppler shift2 in Variant A’？ |
| Intel | Re: InterDigital  Variant B is needed for TRP based pre-compensation scheme, when HST deployment has  (1) SFN-ed TRS that can be used for {*average delay, delay spread}* estimation  (2) non SFN-ed TRS (TRP-specific) that can be used for {*Doppler shift, Doppler spread}* estimation  Note that SFN-ed TRS in (1) is likely to be used in all deployments for backward compatibility with Rel-15/16 UEs or UEs not supporting Rel-17 enhancements |
| CATT | Agree to discuss the variants summarized by feature lead in this meeting and down select in the next meeting.  Regarding the above four variants:   * In Variant A, the delay profile is determined based on measurement of TRS from two TRPs, so scheme 1 has to be adopted * In Variant B, delay and Doppler profiles are deduced from two TRPs respectively. Therefore, it can be used without scheme 1. * The use case for Variant C is not clear to us. * Similar functionality as Variant A and B can be achieved in Variant E. However, eventhough legacy QCL type can be reused in Variant E, additional specification efforts are still needed to indicate UE about how to ignore certain QCL properities.   So, Variant A and B are all acceptable to us. Considering that the application of Variant B doesn’t rely on the use of scheme 1. Variant B is slightly preferred.  In addition, Type B QCL in Rel-15 means {*Doppler shift, Doppler spread*}. So the description of Variant B should be:   * **Variant B**: One of the QCL/TCI state can be associated with {*average delay, delay spread*} ~~(i.e., new QCL-Type-TBD1)~~ and another QCL/TCI state with {*Doppler shift, Doppler spread*} (i.e., ‘QCL-TypeB’) |
| Huawei, HiSilicon | **Fine with updated proposal.**  In our understanding, Variant E seems for UE based solutions, such as Scheme-1. Other Variants are for pre-compensation, and also can be used for the case of NCJT transmission for PDSCH, such as Rel-16 M-TRP transmission.  For CATT’s comment, in our understanding, Variant A can be with or without Scheme-1. Two TRSs to the same DMRS port(s) is for both Scheme-1 and Pre-compensation. The difference is Scheme-1 is UE based, Pre-compensation is NW based. |
| Nokia/NSB | Variant E seems aligned with M-TRP framework in Rel-16.  One dominant TRP cannot be dynamically updates and it should be upto UE implementation.For other options, since this is SFN transmission, delay spread only is not meaningful. Considering all possible paramters including timing, frequency offset and composite of delay spread, UE can determine its receiver parameters. |
| ZTE | Basically we have the same understanding with HW. Variant E is for scheme 1 which is UE based solution. Variant A is for frequency compensation based solution. Both of them should be supported for UE based and network based solutions respectively.  @CATT, the use case of QCL type B is only for CSI-RS for CSI feedback based on Rel-15/16 specification. However, we are discussing PDSCH in which QCL type B never be used. |
| Ericsson | We can agree on supporting Variant E already on this meeting. For Variant A-D, we think they are needed only if pre-compensation has been proved to be beneficial over Rel-15 DPS and Rel-16 M-TRP schemes. Maybe we can get some UE impmentation insight to understand how these Variants can be helpful. |
| FL | Corrected typo in Variant B (the change is in green) |

Based on the discussion on the email reflector proposal #5-1 is further modified.

**Updated proposal 5-1:**

* When the same DMRS port(s) are associated with two TCI states containing TRS as source reference signal, at least one variant is supported for Rel-17 HST-SFN scenario
* **Variant A**: One of the TCI state can be associated with {*average delay, delay spread*}  and another TCI states can be associated with {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA)
* **Variant B**: One of the TCI state can be associated with {*average delay, delay spread*} and another TCI state with {*Doppler shift, Doppler spread*} (i.e., QCL-TypeB)
* **Variant C**: One of the TCI state can be associated with {*delay spread*}  and another TCI states can be associated with {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA)
* **Variant E**: Both TCI states can be associated with {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA)
* FFS: Indication method to apply QCL, e.g., via new QCL-type, or reuse existing QCL-type while UE to ignore certain QCL properties
* Note 1: Each TCI state in the above variants may be additionally associated with {Spatial Rx parameter} (i.e., QCL-TypeD)
* Note 2: Companies are encouraged to provide evaluation results for the above variants based on agreed EVM from RAN1#102e meeting
* Note 4: Above variants are applicable to scheme 1 (if supported) and/or TRP based pre-compensation (if supported) and are used as a reference for evaluation.

## Issue #5-2 (Refinements to the agreements)

Based on the feedback for issues #1-2 and #2-6, majority prefers to support HST enhancements for both PDCCH and PDSCH. Given also that for PDCCH reliability enhancements, it was already agreed to support SFN scheme, it is proposed to remove the brackets for PDCCH in the previous agreements. Finally as commented by one company, it is also recommended to revise the agreement by removing ‘QCL’. The proposed revisions to the previous agreements are provided below.

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| **Agreement**  Support at least the following configuration for HST scenario in Rel-17   * The same DMRS port(s) can associate with multiple ~~QCL/~~TCI states   + Note: DMRS and ~~[~~PDCCH~~]~~/PDSCH from different TRPs are transmitted in SFN manner   + FFS other details   **Agreement**  At most two ~~QCL/~~TCI states are supported for HST scenario in Rel-17   * FFS: Whether to support more than two ~~QCL/~~TCI states for FR2 * FFS configuration/signalling details of the ~~QCL/~~TCI states * Note: DMRS and ~~[~~PDCCH~~]~~/PDSCH from different TRPs are transmitted in SFN manner |

Companies to provide feedback on the above refinements to the agreements.

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| **Company** | **Comment** |
| vivo | We are fine with removing ‘QCL’. |
| Sony | In our view, QCL assumption is a more generic concept than TCI state. TCI state is defined in Spec to conduct all types of QCL assumption to UE. At current stage, UE still have chance to obtain QCL assumption for DMRS port(s), e.g. default QCL assumption, inherited from other signal(s), rather than TCI state.  So we would like to ask the proponent(s) what’s technical reason to remove “QCL” part? |
| Apple | For PDCCH, there is PDCCH for initial acquisition, paging, SI broadcasting, etc, which is typical mandatory for the UE to support. Even if we agree on PDCCH, we should restrict to “PDCCH configured after RRC connection setup” |
| Samsung | Fine with all the refinements.  We think the wording ‘multiple QCL’ may cause unnecessary confusion since the Rel-15 legacy QCL framework allows to configure multiple QCL types in a TCI state: one for QCL-D and the other for the different QCL type. Also, it is unsure on the meaning of QCL. It may mean QCL type, or QCL assumption, or QCL parameter, etc. |
| OPPO | Support the refinement. Even the agreements are for TCI states, we can still discuss default TCI state/QCL assumption later. |
| Qualcomm | Support the updated language of the agreement by removing the QCL and the the support of SFN PDDCH. |
| Huawei, HiSilicon | The changes based on the previous agreements seem unnecessary.  The late agreements can be reflected in further discussion, but no need to back to revise the previous agreements. |
| Nokia/NSB | Regarding to removing “QCL”, since applying two QCL assumption is different from indicating two TCI states, it is better to consider TCI states first. And, add FFS: QCL assumption.  Regarding to PDCCH support,  We have Rel-16 Multi-TRP framesork to indicate two TCI states only for PDSCH. For applying this for PDCCH, we have to define further details on PDCCH TCI update and QCL assumption. In Rel-17, we are developing PDCCH enhancement for M-TRP. At least for TCI indication and QCL assumption, it is beneficial to have common framework. Thus, we are proposing to consider a common framework with Rel-17 PDCCH enhancement for M-TRP. |
| ZTE | This proposal is straightforward, we are fine to support it. However, it is not critical in our view. Even without it, the agreement is clear enough. |
| Ericsson | We prefer to remove the “QCL”. It would be misleading if people read that agreement afterwards, and may even refer to that agreement in some CRs. |

# Other issues

This section contains other issues the companies want to highlight.

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| **Company** | **Comment** |
| Ericsson | For FR2, one TCI state can already be associated with 2 QCL types, based on our understanding, the agreement means 2 TCI states, not 2 QCL.  Proposal l:  At most two ~~QCL/~~TCI states are supported for HST scenario in Rel-17  Proposal 2:  For next meeting, further evaluate gNB pre-compensation scheme comparing with DPS, Scheme 1, and Rel-16 M-TRP schemes based on agreed EVM from RAN1#102e meeting. |
| InterDigital | * + - * Study of adaptive RS transmission in DL, e.g., DMRS, TRS, etc. |
| Qualcomm | * + - * Study of adaptive RS transmission in DL, e.g., DMRS, TRS, etc. |
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