**3GPP TSG RAN WG1 #105-e R1-21xxxxx**

**e-Meeting, May 10th – 27th, 2021**

**Source: Moderator (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 and moderator’s 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]-[23] submitted to RAN1#105-e meeting.

## UE-based solutions



### Issue #1-1 (Identification/Configuration of scheme 1 for PDSCH)

Regarding remaining details of identification/configuration of scheme 1. In RAN1#104b-e meeting dynamic switching for scheme 1 was agreed as UE optional feature. In addition, new RRC parameter for configuration of scheme 1 with indication of two TCI states were agreed for identification of scheme 1. One of the remaining issues is granularity of new RRC parameter configuration, i.e., per BWP, CC or UE. Based on contributions submitted to RAN1#105‑e meeting the following altertives were identified.

**Issue#1-1:** New RRC parameter for identification of scheme 1 PDSCH is configured

* **Alt 1**: Per BWP
  + **Supported by (10)**: CATT, Nokia/NSB, ZTE, vivo, Ericsson, Sony, DOCOMO, LG, Samsung, Huawei/HiSlicon …
* **Alt 2**: Per CC
  + **Supported by (7)**: Qualcomm, InterDigital, OPPO, MediaTek, Lenovo/MotM, Apple, Spreadtrum

#### Round-1

Companies are invited to provide their preference on the remaining details of identification / configuration of scheme 1 for PDSCH.

**Proposal #1-1:**

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs are required |
| InterDigital | Support Alt2 |
| QC | Support Alt2. Per-BWP can lead to dynamic switching between scheme1 and other M-TRP os sTPR transmission schemes if scheme1 is not configured for all BWPs. Also, it is not quite clear what is the motivation or advantages to limit scheme1 only to certain BWP(s). |
| OPPO | Support Alt2 |
| ZTE | Support Alt 1  Since Rel-16 MTRP schemes are configured per BWP, so we also prefer this feature per BWP. |
| vivo | Support Alt1.  Share the same view as ZTE. Since the RRC parameters for R16 MTRP schemes are configured per BWP in *RepetitionSchemeConfig* in *PDSCH-config*, we think it’s better to keep the same principle for scheme 1.  Regarding the dynamic switching of scheme1 and other MTRP or STRP schemes configured in different BWPs, we can configure scheme 1 in all BWPs to avoid it, if UE doesn’t support the dynamic switching. |
| Nokia/NSB | Support Alt 1  For network scheduling flexibility and multi-UE support, the transmission scheme shall be configured per BWP. In case of per CC, do we support SFN scheme for initial BWP? |
| MediaTek | Support Alt 2 |
| Lenovo/MotM | Support Alt2 |
| Apple | Support Alt2 |
| Ericsson | Support Alt 1. Same understanding as ZTE and Nokia. |
| Sony | Support Alt.1.  Same view as vivo that SFN scheme 1 should be configured in parallel with other M-TRP schemes under *PDSCH-Config*.  As for Alt.2 (per CC), we are wondering whether dynamic switch between scheme 1 and M-TRP scheme(s) can still be possible, when X-CC scheduling applied. |
| Spreadtrum | Support Alt2.  For Alt.1, if UE does not support dynamic switching between S-TRP and SFN TRP, and support dynamic BWP switching with different transmission schemes (S-TRP, or SFN) configured, how about UE behaves? |
| Docomo | Support Alt. 1. Same view with ZTE/Nokia/Ericsson. |
| LG | Support Alt1. |
| CATT | Support Alt1.  As raised by ZTE, if dynamic switching is not supported by UE, it can be avoided by implementation,. |
| Samsung | Support Alt.1. |
| Huawei, HiSilicon | We prefer Alt1.  Usually such transmission parameters are configured in BWP level. We don’t see the need to restrict the configuration to per CC. |

#### Round-2

There is slight majority that prefer configuration.

**Proposal #1-1:**

* New RRC parameter for identification of scheme 1 PDSCH is configured per BWP

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| **Company** | **Comment** |
| Moderator | The above proposal is based on majority support. Please note ZTE comment that per BWP configuration is following Rel-16 mTRP principles. |
| Samsung | Support |
| ZTE | Support |
| Docomo | Support |
| QC | Don’t support the FL proposal.   * There is no guarantee that scheme1 is configured across the BWPs which may result into DCI-based switching to other sTPR or M-TRP transmission scheme. * Rel-16 HST-SFN mode is NOT configured on the BWP, rather on the CC level |
| Ericsson | Support FL Proposal |
| LG | Support |
| CATT | Support |
| OPPO | We have similar view as QC.  We have agreed that switching between scheme 1 and 1a/2a/2b/3 is semi-static. For a UE without capability of dynamic switching between scheme 1 and S-TRP, the switching should be also semi-static. If we support per BWP configuration, the switching may be not-semi-static due to dynamic BWP switching. |
| vivo | Support. |
| MediaTek | Don’t support the proposal. We have the same view as QC and OPPO. |
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### Issue #1-2 (Semi-static switching of scheme 1 with single-TRP)

Regarding remaining details of switching of scheme 1 and single-TRP. One company mentioned that UE not capable of supporting dynamic switching should not expect indication of two TCI states per TCI codepoint, while other company propose to introduce RRC parameter to support enabling/disabling of dynamic switching. The company’s proposals regarding remaining details for scheme 1 switching are summarized below.

**Issue #1-2:**

* **Alt. 1:** UE is not expected higher-layer configuration of a single TCI state per TCI codepoint, if UE is configured with scheme 1 PDSCH, but not capable to support dynamic switching with single-TRP
  + **Supported by (14)**: Apple, Interdigital, Qualcomm, OPPO, vivo, Nokia/NSB, Mediatek, Ericsson (with wording change), Sony, Spreadtrum, DOCOMO, LG (with wording update), Samsung, Huawei/HiSilicon
* **Alt. 2:** Dynamic switching of scheme 1 and single-TRP is configured by RRC.
  + **Supported by (2):** CATT, ZTE,

Companies are invited to provide their preference on the remaining details of semi-static switching of single-TRP and scheme 1 for PDSCH.

#### Round-1

**Proposal #1-2:**

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| **Company** | **Comment** |
| Moderator | More inputs are required |
| InterDigital | Support Alt1 |
| QC | Support Alt1 |
| OPPO | Alt 1. |
| ZTE | Alt 2  It is naturally to use a RRC corresponding a UE feature. Even UE support dynamic switching, gNB can still use RRC to disable it. |
| vivo | Support Alt1.  Configuring the number of TCI states in all TCI codepoints of MAC CE as two is a useful way to avoid triggering the dynamic switching for UEs which doesn’t support the dynamic switching. But “*higher-layer configuration of a single TCI state per TCI codepoint*” is not clear for us, because the wording “*TCI codepoint*” is generally described for MAC CE or DCI, RRC is just configured with a TCI state pool with up to 128 single TCI states. Therefore, we suggest modifying Alt. 1 as follows.  • **Alt. 1**: UE is not expected to be indicated by MAC CE with any single TCI state per TCI codepoint, if UE is configured with scheme 1 PDSCH, but not capable to support dynamic switching with single-TRP |
| Nokia/NSB | Support Alt 1. NW doesn’t use any function which is not supported by the UE. This doesn’t need to be specified. It can be noted or concluded rather than the proposal. |
| MediaTek | Support Alt 1 |
| Apple | Support Alt1 |
| Ericsson | If dynamic switching is not supported by a UE, the UE is not expected to be indicated with a single TCI state in DCI. This could be Alt.3. |
| Sony | Support Alt.1.  We think it’s not necessary to additionally introduce RRC parameter for such dynamic switch. The reason is that the TCI codepoints (one TCI state or two TCI states) can be activated/deactivated by NW. |
| Spreadtrum | Alt.1 |
| Docomo | Support Alt.1 updated by vivo.  Irrespective of whether UE supports the dynamic switching, new RRC signaling to enable scheme 1 is needed.  We suggest some update for clarification from vivo’s version.  • **Alt. 1**: UE is not expected to be indicated by MAC CE with ~~any~~ single TCI state per any of TCI codepoint, if UE is configured with scheme 1 PDSCH by RRC, but not capable to support dynamic switching between scheme 1 and ~~with~~ single-TRP |
| LG | Same view with Ericsson with the following modification for the clarification.  “If a UE is configured with scheme 1 PDSCH and dynamic switching is not supported by ~~a~~the UE, the UE is not expected to be indicated with a single TCI state in DCI.” |
| CATT | We agree with Nokia that NW doesn’t use any function which is not supported by the UE, and we also agree with ZTE that even for UE supporting dynamic switching, gNB can still use RRC to disable such functionality.  So, we suggest to revise the proposal in the following way:  Dynamic switching of scheme 1 and single-TRP is configured by RRC, if dynamic switching is supported by a UE. |
| NEC | Support Alt. 1. |
| Samsung | Support Alt.1 and this can be provided by MAC-CE. |
| Huawei, HiSilicon | Support Alt1. |

#### Round-2

**Proposal #1-2:**

* UE is not expected to be indicated by MAC CE with ~~any~~ single TCI state per any of TCI codepoint, if UE is configured with scheme 1 PDSCH by RRC, but not capable to support dynamic switching between scheme 1 and ~~with~~ single-TRP

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| **Company** | **Comment** |
| Samsung | Support the updated FL proposal. |
| Docomo | Support. |
| QC | Support the FL proposal.  Also, think that similar agreement should be reasonable for pre-compensation scheme as well. If so, suggest the following edit:   * UE is not expected to be indicated by MAC CE with ~~any~~ single TCI state per any of TCI codepoint, if UE is configured with scheme 1 PDSCH or TRP-based pre-compensation scheme PDSCH by RRC, but not capable to support dynamic switching between scheme 1 and ~~with~~ single-TRP |
| Ericsson | We still prefer to capture the DCI indication, which is reflecting the previous agreement.  UE is not expected to be indicated by ~~MAC CE~~ DCI with single TCI state in codepoint of the DCI field “Transmission Configuration Indication”, if UE is configured with scheme 1 PDSCH by RRC, but not capable to support dynamic switching between scheme 1 and ~~with~~ single-TRP by TCI state field in DCI 1\_1/1\_2.  Remind all the only dynamic switch we agreed on is by using DCI1\_1/1\_2. We share same view with Nokia, is there any specification update needed?    RAN1#104b-e  **Agreement**   * Support dynamic (DCI-based) switching of scheme 1 (PDSCH) with single-TRP scheme by TCI state field in DCI format 1\_1/1\_2   + This feature is UE optional * FFS all other details including RRC signalling, possible RAN4 impact (if any), etc. |
| LG | Our preference is wrongly captured. If Alt1 is supported, MAC CE for TCI state activation/deactivation is always needed in addition to RRC for configuring scheme 1 or STRP when scheme 1 is changed to STRP or vice versa. However, based on Alt3 suggested by Ericsson, some flexibility can be provided, so we prefer Ericsson’s version. |
| CATT | Support |
| OPPO | We are fine with FL’s proposal 1-2 or the update from QC.  To Ericsson: If single TCI state cannot be indicated by DCI, why gNB activates a TCI codepoint with single TCI state, which will never be indicated? We cannot find any use case for that. |
| vivo | Support the Proposal #1-2.  In our view, if UE has no capability to dynamically switch between scheme 1and STRP, the TCI codepoint with a single TCI state in MAC CE is useless. Therefore, DCI for indicating a single TCI state for PDSCH would not exist in this case. |
| MediaTek | Support |

### Issue #1-3 (Dynamic switching of scheme 1 and scheme-1a)

Regarding support of dynamic switching of scheme 1 and Rel-16 scheme-1a. In RAN1#104b-e meeting it was agreed to support semi-static switching and to further study possible support of dynamic switching. Views on this issue are summarized below.

**Issue#1-3:** Whether or not to support dynamic switching of scheme 1 and Rel-16 scheme-1a

* **Alt 1**: Dynamic (DCI-based) is not supported
  + **Supported by**: Qualcomm, OPPO, NEC, Nokia, Lenovo/MotMobility…
* **Alt 2**: Dynamic (DCI-based) is supported
  + **Supported by**: Huawei, HiSilicon, CATT, …

Based on the preference above the following proposal can be made.

#### Round-1

**Proposal #1-3 (for conclusion):**

* Dynamic switching of Rel-17 scheme 1 and Rel-16 scheme-1a is not supported

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| **Company** | **Comment** |
| InterDigital | Support FL proposal |
| QC | Support FL proposal |
| OPPO | Support the proposal |
| ZTE | Fine with the proposal considering the current situation even though we supported Alt 2. |
| vivo | We are fine with the proposal. |
| Nokia/NSB | Support FL’s proposal. |
| MediaTek | Support |
| Lenovo/MotM | Support FL proposal |
| Apple | Support FL proposal |
| Ericsson | Support FL proposal |
| Sony | Support FL proposal |
| Spreadtrum | Support FL proposal |
| Docomo | We prefer Alt.2, but we are fine with FL proposal. |
| LG | Same view with ZTE/Docomo |
| CATT | Considering the dynamic nature of channel, dynamic switching of 1 and 1a is beneficial to flexibility of system. Furthermore, dynamic witching of 1 and 1a can be supported without extra DCI overhead.  So, Alt 2 is supported. |
| NEC | Support the proposal. |
| Samsung | Support FL proposal |
| Huawei, HiSilicon | We do not support the proposal.  In Rel-16, scheme 1a can be dynamically switched with other schemes. We do not see anything special for scheme 1 here.  Also, dynamically switching between scheme 1 and 1a is beneficial for scheduling to adapt to the varying channel along the track. For low rank environment with LoS, SFN transmission would be more suitable, while for high rank with more NLoS, it’s difficult to align the phases between both TRPs for all layers, so SFN may be less reliable. Therefore, to adapt to changing channels, it's beneficial in terms of spectral efficiency and reliability to switch NCJT and SFN dynamically. |
| Moderator | No more discussion on this issue. Clear majority is OK with this conclusion. |

### Issue #1-4 (Additional source RS in TCI for scheme 1)

In RAN1#104b-e meeting all Rel-15/Rel-16 source RS types supported for TCI states were agreed as working assumption for Rel-17 scheme 1. Several companies proposed to confirm the working assumption in this meeting.

**Issue#1-4:** Whether or not to confirm working assumption on QCL source RS types?

* **Alt-1**: Confirm working assumption
  + **Supported by**: Nokia/NSB, Lenovo/MotMobility,
* **Alt-2**: Not confirm working assumption
  + **Supported by**: …

Based on the inputs above, it is proposed to confirm working assumption from RAN1#104b-e meeting.

#### Round-1

**Proposal #1-4:**

* Confirm working assumption from RAN1#104b-e
  + All QCL source RS resource types as defined in TCI state for Rel-16 multi-TRP are supported for scheme 1.

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| **Company** | **Comment** |
| InterDigital | Support FL proposal |
| OPPO | Fine. |
| ZTE | Support |
| vivo | Support the proposal |
| Nokia/NSB | Support FL’s proposal. |
| MediaTek | Support |
| Lenovo/MotM | Support |
| Apple | Support FL proposal |
| Ericsson | We are fine with the proposal |
| Sony | Support FL proposal |
| Spreadtrum | Support FL proposal |
| Docomo | Support |
| LG | Support |
| CATT | Support |
| NEC | Support |
| Samsung | Support FL proposal |
| Huawei, HiSilicon | Support. |
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### Issue #1-5 (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 provided LLS evaluation results comparing performance of scheme 2 with scheme 1 and the baseline scheme. Summary of the company’s views are provided below:

**Issue#1-5:** Whether to support scheme 2 in Rel-17?

* Scheme 2 is supported
  + **Supported by**: InterDigital, Intel …
* Scheme 2 is not supported / low priority
  + **Supported by**: Apple, Sony, Nokia/NSB, Qualcomm, …

Since there is no clear majority to support scheme 2 in Rel-17, it is recommended to make the following conclusion on Issue #1-5.

#### Round-1

**Proposal #1-5 (for conclusion):**

* Scheme 2 is not supported in Rel-17

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| **Company** | **Comment** |
| Moderator | No more discussion on this issue |
| QC | Support the conclusion. |
| QC | Support the conclusion. |
| Nokia/NSB | Support the conclusion. |
| MediaTek | Support |
| Apple | Support FL proposal |
| Ericsson | We are fine with the proposal |
| Sony | Support FL proposal |
| Spreadtrum | Support FL proposal |
| Docomo | Support |
| CATT | Support the conclusion. |
| Samsung | Support FL proposal |
| Huawei, HiSilicon | Support. |
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### Other issues

This section contains other issues that companies want to highlight for discussion regarding support of UE-based schemes.

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| **Company** | **Comment** |
| QC | We should clarify and discuss the QCL assumptions between the TRS/CSI-RS and SSB reference RS for scheme 1.  That is an extremely important aspect that should be discussed. For some UE implementations where both SSB and TRS are used for time/frequency tracking purposes, there is ambiguity and confusion since SSB and TRS could have different Doppler shift/spread and average delay or delay spread depending on how gNB is sending the SSB blocks across the TRPs. |
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## TRP-based solutions

### Issue #2-1 (QCL types/assumptions when TRS is source)

Regarding new QCL types/assumption for TRS, when TRS resource(s) is used as source RS in the TCI state. The following preference on the QCL Variants (A, B, C and E agreed in RAN1#103-e meeting) were provided by companies for TRP-based pre-compensation schemes. In addition, one company proposed a new option (captured as Variant F) for QCL types/assumption.

**Issue#2-1:** For TRP-based pre-compensation, 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**
  + **Supported by (12)**: Huawei / HiSilicon, OPPO, Spreadtrum, CATT, Futurewei, ZTE, CMCC, Ericsson, Samsung, Lenovo/Motorola Mobility, Nokia/NSB, LGE, …
* **Variant B** (5)
  + **Supported by**: CATT, Intel, Ericsson, Qualcomm, ZTE …
* **Variant C** (2)
  + **Supported by**: vivo, CMCC, …
* **Variant E** (2)
  + **Supported by**: Futurewei, Samsung …
* **Variant F (new) (2)**
  + One of the TCI state can be associated with {average delay, delay spread, [Doppler spread]} and another TCI state can be associated with {average delay, delay spread, Doppler shift, Doppler spread} (i.e., QCL-TypeA)
  + **Supported by**: Apple, Interdigital,

Based on the company’s preference the following proposal is made.

#### Round-1

**Proposal #2-1:**

* Variant A (based on RAN1#103-e meeting agreement) is supported as QCL types/assumption, when the same DMRS port(s) are associated with two TCI states containing TRS as source reference signal.
  + FFS support of other Variant(s)

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| **Company** | **Comment** |
| InterDigital | * Don’t support the proposal. * We believe variant E is a better choice as it has a symmetric QCL type for both TRP1 and TRP2. As a UE moves from TRP1 to TRP2, for other variants, we have to alternate the association of QCL Type A as the source of Doppler estimation; hence unnecessary signaling. * With variant E, we could assume that each UE has sufficient intelligence to know which of TRPs should be used as the source of Doppler estimation, and what parameters should be dropped. * Also to make a sound decision on this issue, it may be better to first discuss and agree on whether TRS is going to be pre-compensated or not. |
| QC | Don’t support the proposal.   * Both variant A and variant B should be supported. * Variant B is preferred for backward compatibility of supporting Rel.15/16 UEs with SFN TRS while enabling a UE friendly implementation for Rel.17 UE where the SFN TRS is used for deriving the time tracking loops (for delay spread and average delay) with the other TRS (from anchor TRP) is used for deriving the frequency tracking loop. |
| OPPO | Support the proposal.  Since PDSCH will only be compensated in one of the TRPs, the PDSCH can only be QCLed to the TRP without compensation via TypeA. It is a risk for UE to decide which TRS to be used as source RS for Doppler estimation. |
| ZTE | We support both Variant A and B.  For Variant A, it can save TRS overhead, but may cause more UE complexity. For Variant B, it is friendly to UE and may have backward compatibility with legacy SFN TRS. |
| vivo | Support Variant C.  We still have a concern about the redundant {avarage delay} reference of the non-anchored TRP in Variant A.  Besides, compared with Variant A/C, Variant B needs additional spec effort to support the QCL-typeB relationship between PDSCH/PDCCH DMRS and TRS, which is only applied for the case of CSI-RS QCLed with TRS in R15/16. |
| Nokia/NSB | Support FL’s proposal. Also agree with OPPO’s comment. |
| MediaTek | Support the proposal |
| Lenovo/MotM | Support the proposal. In our understanding both variants provide the same performance for Rel. 17 UEs, and assuming Variant A, configuring a third TRS for legacy UEs should not be a notable burden on the network. However, the selection of either Variant A (TRP specific TRS) or Variant B (SFN TRS) is related to whether we would want to support dynamic switching to Scheme 1 and/or single-TRP scheme (Issue #2-5) |
| Apple | We do not have strong preference. Both Variant A and Variant B looks reasonable. |
| Ericsson | We slightly prefer variant A , but are fine to support both |
| Sony | We tend to agree that it’s better to also support legacy UEs. But procedure-wise, whether TRS can be transmitted in SFN manner should be decided first. |
| Spreadtrum | In principle, fine with the proposal.  We have agreed Variant E for scheme 1. The proposal here is for gNB Doppler pre-compensation scheme. Thus, we suggest the following revisions for the proposal: **Proposal #2-1:**   * For TRP-based pre-compensation, Variant A (based on RAN1#103-e meeting agreement) is supported as QCL types/assumption, when the same DMRS port(s) are associated with two TCI states containing TRS as source reference signal.   + FFS support of other Variant(s) |
| Docomo | Support |
| LG | Support FL’s proposal.  Variant A and Variant B provide the same functionality. So, in our perspective, supporting of one of them is sufficient. |
| CATT | We have similar view as QC and ZTE, both Variant A and B should be supported. |
| NEC | Support the proposal. |
| Samsung | Support FL proposal |
| Huawei, HiSilicon | We support the proposal. |
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#### Round-2

**Proposal #2-1a:**

* For TRP-based pre-compensation, Variant A (based on RAN1#103-e meeting agreement) is supported as QCL types/assumption, when the same DMRS port(s) are associated with two TCI states containing TRS as source reference signal.
  + FFS support of other Variant(s)

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| **Company** | **Comment** |
| Moderator | Considering majority of companies supports Variant A only and this QCL option is sufficient to address all scenarios, my recommendation is to agree on the Proposal #2-1a. Note that this issue has been discussed several meetings and it is time to make a decision. |
| Samsung | Support the updated FL proposal. |
| ZTE | We prefer to additionally support Variant B for the sake of less UE complexity and good backward compatibility |
| Docomo | Support FL proposal. |
| QC | Variant A and variant B represent two different schemes for TRS  For sake of progress, *strongly suggest* supporting both variants to enable different deployments (both TRP-specific TRS and BC) and specification flexibility. Also to further clarify, it is expected that UE is configured with only one variant when TPR-based pre-compensation is configured (i.e., no dynamic switching between the two variants).   * For TRP-based pre-compensation, Variant A and Variant B (based on RAN1#103-e meeting agreement) are supported as QCL types/assumption, when the same DMRS port(s) are associated with two TCI states containing TRS as source reference signal.   + FFS support of other Variant(s)   + UE is expected to be configured with only one variant when TRP-based pre-compensation scheme is configured. |
| Ericsson | Support |
| LG | Support FL’s proposal |
| CATT | Agree with ZTE and QC that both Variant A and B should be needed. So, we also prefer to support Variant B additionally. |
| OPPO | Support the proposal with Variant A only. We fail to see the benefits to support both. |
| vivo | Variant C should be supported, which can avoid ambiguity of downlink timing and provide more timing imprecision. |
| MediaTek | Support |

### Issue #2-2 (New QCL types/assumption)

Regarding signalling of QCL type/assumptions for TRP-based pre-compensation scheme. The following two approaches were identified by companies for TRP-based pre-compensation scheme as captured in Alt 1 and Alt 2.

**Issue#2-2:** For TRP-based pre-compensation QCL assumptions is provided to the UE by using

* **Alt-1**: New QCL type
  + **Supported by (5)**: Huawei / HiSilicon, Lenovo/MotMobility, Intel, vivo (slightly), Ericsson
* **Alt-2**: The existing QCL type(s) with certain QCL parameters dropped from the indicted QCL type
  + FFS rule or signalling to determine which TCI state with dropped QCL parameters
  + **Supported by (12)**: ZTE, Sony, Nokia/NSB, OPPO, LGE, Docomo, CATT, NEC, Samsung, Apple, Qualcomm, Ericsson (2nd preference),…

Companies are invited to share their preference regarding signaling option of QCL types/assumptions for TRP-based pre-compensation scheme.

#### Round-1

**Proposal #2-2:**

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| **Company** | **Comment** |
| Moderator | More inputs are required |
| InterDigital | Should be discussed later. |
| QC | Considering that pre-compensation is not ideal where the pre-compensated DL signal from the other TRP is not aligned to the frequency offset of the DL signal from the first TRP as well as it may have different Doppler spread, we think that Alt-2 may be a better choice.    So, the UE may ignore certain QCL parameters = {DopplerSpread, Doppler shift} from one of the TCI. And a simple rule (e.g first TCI state) could be utilized. |
| OPPO | Support Alt 2. We can agree on Issue#2-1 first. |
| ZTE | Support Alt 2.  Introducing a new QCL type will lead to a new TCI state. In such case, TCI sharing will be a problem, the support/configured/activated maximum number of beams will be reduced if the number of TCI states in Rel-15/16 is maintained.  Taking an extreme case as an example in which a UE only supports two TRS .  If new QCL type is introduced, to support SFN and STRP , at least three TCI states should be activated where TCI state 1 includes TRS 1 with QCL type A, TCI state 2 includes TRS 2 with QCL type A, and TCI state 3 includes TRS 1 with the new QCL type E.    For SFN , TCI state 1 and 3 should be indicated. For STRP , either TCI sate 1 or 2 can be indicated to UE .  However, if Alt 2, e.g. UE just ignores Doppler shift and spread from the first TCI state in the case when Rel-17 SFN is enabled by RRC and two TCI states are indicated by DCI , only two activated TCI states are enough.  Given that the maximum activated/configured TCI states are limited, the flexibility of Alt1 is less especially in FR2 |
| vivo | Slightly prefer Alt-1 due to a more natural QCL indication following the R15/16 design principle. |
| Nokia/NSB | Support Alt 2,  Because we don’t support dynamic switching with other schemes, indicating two TCI states is already enough. There needs to be some indication of which TCI state {DopplerSpread, Doppler shift} is dropped from, e.g., as suggested by QC. |
| MediaTek | Support Alt 2 |
| Apple | Support Alt2 |
| Ericsson | Either one is probably fine, Alt.2 needs further details on how to indicate to the UE. For variant B, need to add QCL type C to TCI state for PDSCH |
| Sony | Support Alt 2.  If reusing existing QCL types (with UE dropping certain parameters) can be supported for TRP-specific pre-compensation, Variant E (TypeA + TypeA, already supported for scheme 1 PDCCH with TRS as source RS) can be used to support any other variant. |
| Spreadtrum | Depending on proposal 2-1 |
| Docomo | Either is fine, but slightly prefer Alt.2. |
| LG | Support Alt2. |
| CATT | We have similar view as ZTE, Alt.2 is preferred. |
| NEC | Support the proposal, and prefer Alt-2. |
| Samsung | Support Alt.2. |
| Huawei, HiSilicon | We support Alt1 as it will be more clear by following the legacy TCI framework. If ignoring is possible, there should be no QCL type B/C at all.  -     'typeA': {Doppler shift, Doppler spread, average delay, delay spread}  -     'typeB': {Doppler shift, Doppler spread}  -     'typeC': {Doppler shift, average delay}  -     'typeD': {Spatial Rx parameter} |

#### Round-2

**Proposal #2-2:**

* For TRP-based pre-compensation QCL assumptions is provided to the UE by using the existing QCL type(s) with certain QCL parameters dropped from the indicted QCL type
  + FFS rule or signalling to determine which TCI state with dropped QCL parameters

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| **Company** | **Comment** |
| Moderator | Considering majority of companies supports Alt 2 and there is no issues/limitation identified for this approach, my recommendation is to agree on the Proposal #2-2 with Variant A. Note that this issue has been discussed several meetings and it is time to make a decision. |
| Samsung | Support the updated FL proposal. |
| ZTE | Support the proposal  It is noted that QCL-type B and C are not used for PDSCH/PDCCH TCI indication as we pointed it out before  ---------38.214----  For the DM-RS of PDCCH, the UE shall expect that a *TCI-State* indicates one of the following quasi co-location type(s):  - 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with the same CSI-RS resource, or  - 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with a CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition*, or  - 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured without higher layer parameter trs-Info and without higher layer parameter *repetition* and,when applicable, 'typeD' with the same CSI-RS resource.  For the DM-RS of PDSCH, the UE shall expect that a *TCI-State* indicates one of the following quasi co-location type(s):  - 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with the same CSI-RS resource*,* or  - 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with a CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition*,or  - typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured without higher layer parameter *trs-Info* and without higher layer parameter *repetition* and, when applicable, 'typeD' with the same CSI-RS resource |
| Docomo | Support |
| QC | Support the FL proposal.   * For variant B, as highlighted by ZTE and Ericsson, there is need to add QCL TypeB to TCI state for PDSCH/PDCCH. * The rule for determining/signalling to determine which TCI state with dropped QCL parameters depends on the variants A/B/C. |
| Ericsson | Given this is majority opinion and the functionality would be the same, we can accept this proposal. It will be difficult to switch between pre-compensation and Scheme 1 via DCI dynamically, is that understanding shared with this group? |
| LG | Support the proposal |
| CATT | Support the proposal |
| OPPO | Support the proposal. |
| MediaTek | Support the proposal. |
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### Issue #2-3 (Indication of the carrier frequency for UL)

Regarding indication of the carrier frequency for UL transmission. In RAN1#104b-e it was agreed to support at least one option based on implicit and explicit approaches for indication of the carrier frequency for UL. Companies preference regarding the above options are summarized below.

**Issue#2-3:** Indication of carrier frequency for uplink transmission in TRP-based pre-compensation schemes

* **Option 1** Implicit from RAN1#102-e agreement
  + **Supported by**: Futurewei, OPPO, CATT, CMCC, ZTE, Qualcomm (with loose QCL type E), Intel (with RAN4 tests to address FO pre-compensation errors), Samsung, InterDigital, Apple, vivo, LGE
  + **Companies with concerns**: Nokia/NSB,
* **Option 2** Explicit from RAN1#102-e agreement
  + **Supported by**: Futurewei, Ericsson, Sony, ZTE (specification impact should be as small as possible), Intel, Qualcomm (only if UE optional feature), Nokia / NSB, NTT DOCOMO, vivo (UE feature) , …
  + **Companies with concerns**: Huawei/HiSilicon, CATT, OPPO?, Lenovo/MotMobility

Companies are invited to share their views regarding indication option of the carrier frequency for UL transmission.

#### Round-1

**Proposal #2-3:**

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs are required |
| InterDigital | Both should be supported, where the baseline should be the Implicit indication but to be assisted by explicit if needed. |
| QC | Implicit method (based on UL RS) should be the basic feature and additionally (if needed and justified) explicit reporting can be supported ONLY as optional UE feature.  Also, given the current progress in RAN1 on HST agenda, we have strong concerns that RAN1 may not be able to complete the work on CSI-reporting of Doppler shift/frequency.  Also, to improve the accuracy of frequency estimation, SRS enhancement should be further studied. As discussed in our tdoc, a new SRS pattern of two (or more) SRS symbols with a configurable gap helps with higher accuracy and more reliable estimation of Doppler frequency shift. |
| OPPO | The standardization effort of additional enhancement for CSI feedback is too large, while Option 1 can have no specification impact. The gain of TRP based pre-compensation is not significant enough to be worth the effort. We cannot even find direct evaluation result in contributions to justify the gain of Option 2. |
| ZTE | Option 1 should be supported as the baseline.  If option 2 is agreed, it should be under CSI report framework, otherwise, we doubt it can be finished in Rel-17. |
| vivo | At least support option 1, option 2 could be a UE capability. |
| Nokia/NSB | Support Option 2 for accuracy. We don’t see QC’s new SRS design reduces the overhead. Using more SRS symbol with the existing SRS specification shall be used for option 1. |
| Lenovo/MotM | Support Option 1. Agree with QC/OPPO/ZTE, the specification impact of Option 2 is significant |
| Apple | Option 1 can be the starting point, |
| Ericsson | Support Option 2.  Benefits with Option 2 include:   * Support not only TDD, but also FDD in which UL and DL frequency difference can be up to 600MHz (e.g., band n92 DL: 832 MHz – 862 MHz, UL; 1432 MHz – 1517 MHz) and pre-compensation based on UL SRS Doppler estimation can be too much off * Support DL CA, in which UL may not be available for a DL carrier, and pre-compensation cannot be done based on UL measurement * It is more reliable when UL coverage is limited * Ul feedback overhead is small, 10 bits is enough (see table below) , which is comparable to RSRP report, very frequent reporting is not needed since Doppler changes slowly around the middle point of two TRPs (see figure below)   Required standardization effort:   * Minimum effort is needed * Reuse the CSI framework, changes include   + Introduce a new report quantity for Doppler reporting   + Use TRS as CMR in CSI report setting   + Use one of the existing CSI timeline tables, e.g., the one for RSRP/SINR, for a-CSI   + CPU occupation can follow the existing rules for RSRP/SINR   Table 1: DL Rx frequency difference between two TRPs and the number of bits required for report the difference with a 20Hz frequency resolution.   |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | Doppler (Hz) | | | max |fd1-fd2| (Hz) | max|f\_tx1-f\_tx2| (Hz) | max |f\_rx1-f\_rx2| (Hz) | # of steps | # of bits | | f0 (GHz) | 500 km/h | 100 km/h | 50 km/h | 500km/h | +/-0.05ppm |  | step size = 20Hz | | | 1 | 463 | 93 | 46 | 926 | 100 | 1026 | 103 | 7 | | 2 | 926 | 185 | 93 | 1852 | 200 | 2052 | 205 | 8 | | 3 | 1389 | 278 | 139 | 2778 | 300 | 3078 | 308 | 9 | | 4 | 1852 | 370 | 185 | 3704 | 400 | 4104 | 410 | 9 | | 5 | 2315 | 463 | 231 | 4630 | 500 | 5130 | 513 | 10 | | 6 | 2778 | 556 | 278 | 5556 | 600 | 6156 | 616 | 10 |   Table 2 Overhead analysis for reporting the doppler difference using PUCCH format 3   |  |  |  |  | | --- | --- | --- | --- | | **PUCCH format 3** |  |  |  | | # of RBs | 1 | # of UEs | 100 | | # of symbols | 7 | Report period (ms) | 20 | | # of DMRS symbols | 2 | # of UE per slot | 5 | | # of data symbols | 5 | # of RBs | 5 | | # of REs for data | 60 | BW (RBs) | 50 | | # of encoded bits | 120 | overhead | 5% | | UCI payload (bit) | 10 |  | | | code rate | 0.083 |  |  | |
| Sony | Support Option 2.  Thanks to the numerical analysis from Ericsson, we somehow feel confident that UE Doppler frequency reporting can be kicked off in Rel.17, if supported. |
| Spreadtrum | Support option 1. There are too many specification work to be done for option2. |
| Docomo | We are more interested in FDD band in FR1 to deploy HST-SFN, hence we support option 2. |
| LG | Support Option 1.  Option 2 can increase UE complexity due to quantization and reporting of Doppler shift. If my understanding is correct, one of the motivations of supporting TRP-based scheme is to reduce UE complexity. So, Option 1 can be more suitable option for that purpose. |
| CATT | Only option 1 is supported.  According our simulation results, it can be seen that obvious performance gain can be achieved by using uplink signal(s) transmitted on the carrier frequency acquired in the 1st step. That is, option 1 is sufficient to ensure the estimation accuracy.  Moreover, the overhead and delay for CSI reporting and overhead of TRS of implicit Doppler shift reporting (i.e., option 1) is less than explicit Doppler shift reporting (i.e., option 2). |
| NEC | Support option 1. |
| Samsung | Support Option 1 for baseline scheme of UL carrier frequency indication and consider Option 2 later if needed. |
| Huawei, HiSilicon | Support option 1, and it has been supported in spec without any further spec impact.  As shown in our contribution (R1-2104269), option 1 has provide sufficient performance, which is very close to the performance with ideal frequency shift estimation. Therefore, option 2 is not needed. |

#### Round-2

**Proposal #2-3:**

* Indication of carrier frequency for uplink transmission in TRP-based pre-compensation scheme is supported using Option 1 and Option 2
  + **Option 1** Implicit from RAN1#102-e agreement
    - FFS enhancements to SRS to improve the accuracy of frequency estimation
  + **Option 2** Explicit from RAN1#102-e agreement
    - Option 2 is supported as a separate optional UE feature
    - FFS the following details
      * New report quantity for Doppler reporting
      * TRS as CMR in CSI report setting
      * CSI timeline tables, e.g., the one for RSRP/SINR, for a-CSI
      * CPU occupation can follow the existing rules for RSRP/SINR
  + Note: If details of Doppler reporting in Option 2 are not finalized by end of RAN1#107e, Option 2 is not supported in Rel‑17

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| **Company** | **Comment** |
| Moderator | The above proposal is possible compromise to move forward. |
| Samsung | We cannot see the need of FFS point in Option 1 hence it should be deleted. Regarding Option 2, it can be FFS at this time since lots of companies are worried about a significant spec. impact. |
| ZTE | We are fine with the proposal |
| Docomo | We are fine with the proposal |
| QC | Support in principles, however, we would like to prioritize option 1 and make it the baseline/basic solution. Suggest following note:   * Note: Option 1 is prioritized, if details of Doppler reporting in Option 2 are not finalized by end of RAN1#107e, Option 2 is not supported in Rel‑17 |
| Ericsson | Support FL proposal. We disagree with the priority suggested by QC. The UE report of doppler shift is at least equally important, if not more important, than SRS enhancement. Enabling the UE reporting is essential for FDD and CA operation in HST network, it is also an essential solution for low UL SNR with small overhead and better reliability. For SRS based measurement, RAN1 work is to optimize the existing SRS signaling which we still need to confirm if there is gain  We’ve pointed out that the doppler report can simply reuse the CSI framework, straightforward, and confident about we could finalize major details of the design. However, we don’t think put a dedicated timeline for this specific functionality is a proper approach. |
| CATT | Support option 1. |
| OPPO | We suggest agreeing on option 1 first in this meeting.  We cannot observe performance gain of TRP pre-compensation using option 2 over option 1. According to our evaluation, even with large Doppler estimation error, the performance is not significantly impacted. Further evaluation is needed for that. We didn’t have time to perform sufficient evaluation due to short interval between these two meetings. |
| vivo | We are fine with the proposal |
| MediaTek | Support the proposal |

### Issue #2-4 (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 provided their views whether carrier frequency requires specification support for indication or can be selected by the UE based on implementation. Company’s preferences on this issue are summarized below:

**Issue#2-4:** Whether to support QCL-like association between DL and UL RS?

* **Option 1**: 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 between the following alternatives:
  + **Alt-1**: Explicit indication of the DL RS for QCL-like association
  + **Alt-2**: Implicit indication of DL RS for QCL-like association
  + **Supported by**: Futurewei, CMCC, Qualcomm, …
* **Option 2**: 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
  + **Supported by**: vivo, CATT, Ericsson, Samsung, Intel, OPPO, Sony, LGE, Nokia/NSB, …

Based on the company’s preference above, the following proposal is made.

#### Round-1

**Proposal #2-4 (for conclusion):**

* For Variant A, B or C (if supported)
  + For frequency offset pre-compensation 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

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| **Company** | **Comment** |
| InterDigital | Support Option 2. It should not be indicated; for a UE in pre-compensation mode it should be assumed by definition. |
| QC | To further discuss after making progress on issues #2-1 and #2-2 |
| OPPO | Support the proposal. |
| ZTE | To further discuss |
| vivo | Support |
| Nokia/NSB | Support option 2. RAN4 doesn’t specify any requirement on UL carrier frequency with DL QCL parameters. This is up to UE implementation. |
| MediaTek | Support the proposal |
| Lenovo/MotM | Agree with QC, should be discussed after a decision is made on Proposal 2-1 |
| Ericsson | Support the proposal |
| Sony | Support FL proposal |
| Spreadtrum | Support FL proposal |
| Docomo | Support the proposal, but also fine to discuss it after issue #2-1 and #2-2. |
| CATT | Support the proposal |
| NEC | Support the proposal. |
| Samsung | Support FL proposal |
| Huawei, HiSilicon | Support FL’s proposal. |

### Issue #2-5 (Switching of TRP pre-compensation scheme)

Some companies have provided their views regarding switching of TRP pre-compensation scheme with legacy Rel-15/Rel-16 and new Rel-17 transmission schemes. Company’s views on this issue are summarized below:

**Issue#2-5:** How to support switching of TRP pre-compensation with other Rel-15/Rel-16/Rel-17 schemes?

* Switching of TRP-based frequency offset pre-compensation and Rel-15 singe-TRP
  + **Alt. 1-1**: Dynamic (DCI-based)
    - **Supported by**: Spreadtrum (with UE capability), Nokia/NSB, Lenovo/MotMobility,
  + **Alt. 1-2**: Semi-static (RRC-based)
    - **Supported by**: Apple, Qualcomm…
* Switching of TRP-based frequency offset pre-compensation and Rel-16 scheme 1a/2a/2b/3/4
  + **Alt. 2-1**: Dynamic (DCI-based)
    - **Supported by**: …
  + **Alt. 2-2**: Semi-static (RRC-based)
    - **Supported by**: Apple, Qualcomm, Lenovo/MotMobility,…
* Switching of TRP-based frequency offset pre-compensation and Rel-17 scheme 1
  + **Alt. 3-1**: Dynamic (DCI-based)
    - **Supported by**: Spreadtrum?, Lenovo/MotMobility,…
  + **Alt. 3-2**: Semi-static (RRC-based)
    - **Supported by**: Apple, Qualcomm,

Companies are invited to share their preference regarding switching of TRP pre-compensation scheme with other transmission schemes. One possible option is to support the same switching options as were agreed for scheme 1 (PDSCH). In addition to support semi-static switching of Rel-17 scheme and TRP pre-compensation.

#### Round-1

**Proposal #2-5:**

* For specification based TRP-based frequency offset pre-compensation scheme
* Support dynamic (DCI-based) switching with single-TRP scheme by TCI state field in DCI format 1\_1/1\_2
  + This feature is UE optional
* Support semi-static (RRC based) switching with Rel-16 schemes 1a, 2a, 2b, 3, 4
* Support semi-static (RRC based) switching with Rel-17 scheme 1 (PDSCH)

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| **Company** | **Comment** |
| InterDigital | We don’t think dynamic indication for switching to S-TRP is needed, as occasional reception by only one TRP should be natural to a M-TRP system.  Support 2nd and 3rd bullets. |
| QC | We share similar views as InterDigital. It is not clear to us why dynamic switching needed to single-TRP. |
| OPPO | Support the proposal to be consistent with scheme 1. |
| ZTE | Support the proposal to be consistent with scheme 1.  Moreover, scheme 1 and this pre-compensation scheme should not be configured simultaneously. |
| vivo | Support the proposal excluding the 3rd bullet.  We should first clarify whether pre-compensation and scheme 1 use the same RRC parameter or two different RRC parameters?  In our view, since they are both SFN schemes, we can consider indicating them with the same parameter.  **Proposal #2-5:**   * For specification based TRP-based frequency offset pre-compensation scheme * Support dynamic (DCI-based) switching with single-TRP scheme by TCI state field in DCI format 1\_1/1\_2   + This feature is UE optional * Support semi-static (RRC based) switching with Rel-16 schemes 1a, 2a, 2b, 3, 4 * FFS: Support semi-static (RRC based) switching with Rel-17 scheme 1 (PDSCH) |
| Nokia/NSB | Support FL’s proposal.  Regarding to vivo’s addition, we can add note that Rel-17 scheme 1 and pre-compensation scheme are not configured simultaneously. With the above note, if UE support both schemes, RRC based switching is already supported. |
| MediaTek | Support the proposal |
| Lenovo/MotM | Defer discussion until after Proposal 2-1 is finalized. The switching complexity depends on the pre-compensation scheme details. For example, whether TRP specific TRS or an SFN TRS is assumed would impact the complexity of switching to/from Scheme 1 and single-TRP scheme. |
| Apple | We still do not fully understand how DCI based switching can work in a worthwhile way.  The issue with pre-compensation based and sTRP DPS based is that, unlike the scheme 1, and TRS QCL is different.  One TRS would have TypeA, and the other TRS would have some special QCL very likely at least not including doppler shift.  So to make the dynamic switching truly work, this seems to suggest that gNB needs to send the third TRP which means UE has to simultaneously track 3 TRS.  Maybe the proponent can explain how this can work in the field   1. What is the TRS configuration, and the QCL property of teach TRS 2. How gNB switch between this two modes, meaning, based on what input.   But in general, the FL proposal looks not bad to us. |
| Ericsson | Support dynamic switching, similar to the agreement made for Scheme 1.  Dynamic switching is required when UL signal from the other TRP is very weak from one TRP (e.g., a UE is very close to the other TRP, or due to channel fading) and UL frequency estimation at the TRP is unreliable, in this case gNB may want to switch to sTRP transmission. |
| Sony | It seems the semi-static switching with Rel.16 schemes and Rel.17 scheme 1 are fine.  But as for dynamic switch with S-TRP, given the concern from Apple, it would be safe to study the impact of TRP-specific pre-compensation, when Variants (A/B/C/E/F) associated with such pre-compensation scheme are not fully decided yet. |
| Spreadtrum | Support FL proposal. Follow the same principle with scheme 1. |
| Docomo | Support the proposal to be consistent with scheme 1. |
| LG | Support FL’s proposal. |
| CATT | Similar view as OPPO, it should be consistent with scheme 1.  Regarding the switching with Rel-17 scheme 1, we think it should be discussed later. |
| NEC | Support the proposal. |
| Samsung | Support FL proposal which has consistency with scheme 1. |
| Huawei, HiSilicon | We support dynamic switching. Even in current spec, the use of a certain QCL combination is just indicated by TCI codepoints in DCI, after the RRC configuration. |

#### Round-2

**Proposal #2-5:**

* For specification based TRP-based frequency offset pre-compensation scheme
* Support dynamic (DCI-based) switching with single-TRP scheme by TCI state field in DCI format 1\_1/1\_2
  + This feature is UE optional
* Support semi-static (RRC based) switching with Rel-16 schemes 1a, 2a, 2b, 3, 4
* Support semi-static (RRC based) switching with Rel-17 scheme 1 (PDSCH)

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| **Company** | **Comment** |
| Moderator | The proposal is the same as in 1st round of the discussion. We may not have time to repeat the discussion we had for scheme 1. Please indicate whether you have strong concern on the current proposal and if, yes, your modifications that would make the proposal acceptable. |
| Samsung | Support the proposal. It makes consistent design with scheme 1. |
| ZTE | Support |
| Docomo | Support. Agree with Moderator that we don’t need to repeat the discussion. Proposal 2-5 is consistent design with scheme 1. |
| QC | Fine with the proposal. |
| Ericsson | Support |
| LG | Support |
| CATT | Support |
| OPPO | Support |
| vivo | We would like to clarify that we don’t support the dynamic switching of pre-compensation with scheme 1 (PDSCH) first. But we still have the concern on the 3rd bullets, since it depends on the agreement on issue #2-2. We can defer the discussion pending resolution for issue #2-2. |
| MediaTek | Support |
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### Issue #2-6 (Configuration/Identification of TRP pre-compensation scheme)

Some companies have provided their views regarding configuration/identification of TRP pre-compensation scheme for PDSCH. Company’s views on this issue are summarized below:

**Issue#2-6:** TRP pre-compensation scheme for PDSCH is identified by

* **Alt-1**: Number of TCI states
  + **Supported by**: …
* **Alt-2**: New RRC parameter and number of TCI states
  + **Supported by**: Nokia/NSB, …

#### Round-1

Companies are invited to provide their preference on the above alternatives. One possible option is to support the same configuration/identification approach as for scheme 1 (PDSCH) as captured in the proposal below.

**Proposal #2-6:**

* RRC parameter and number of TCI states are used for identification of TRP-based frequency offset pre-compensation scheme
  + FFS other details

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| **Company** | **Comment** |
| InterDigital | Support FL proposal |
| QC | Support FL proposal |
| OPPO | Support the proposal |
| ZTE | Support the proposal |
| vivo | Suggesting clarify whether pre-compensation and scheme 1 use the same RRC parameter or two different RRC parameters first. |
| ZTE | Support the proposal |
| MediaTek | Support the proposal |
| Lenovo/MotM | Support |
| Apple | We are fine with the DL proposal |
| Ericsson | It may depend on the outcome of issue #2-2. If a new QCL type is introduced, then RRC configuration may not be necessary and pre-compensation can be indicated by the new QCL type. Otherwise, a RRC parameter would be needed. |
| Sony | Same view with Ericsson that when UE is activated with new QCL type or some UE dropping rule applied, it may implicitly indicate UE that TRP-specific pre-compensation is carried out at NW side. |
| Spreadtrum | Support the proposal |
| Docomo | Support, but also agree with Ericsson. |
| LG | Support the proposal |
| CATT | Support the proposal |
| NEC | Support the proposal. |
| Huawei, HiSilicon | Not clear about this proposal. Should TCI number of pre-compensation scheme be the same as other multi-TRP schemes? |
| Moderator | Re Huawei. The wording is reused from scheme 1 agreement. The number of TCI states is two for TRP based pre-compensation. |

#### Round-2

**Proposal #2-6:**

* RRC parameter and number of TCI states are used for identification of TRP-based frequency offset pre-compensation scheme
  + FFS other details

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| **Company** | **Comment** |
| Moderator | Let’s defer the discussion pending resolution for issue#2-1. |
| CATT | If this proposal is for PDSCH only, we suggest to clarify it:  **Proposal #2-6:**   * RRC parameter and number of TCI states are used for identification of TRP-based frequency offset pre-compensation scheme for PDSCH   + FFS other details |
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### Other issues

This section contains other issues that companies want to highlight for discussion regarding support of TRP-based pre-compensation scheme.

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| **Company** | **Comment** |
| QC | UL SRS enhancement to improve Doppler shift estimation. Based on our evaluation, introducing two SRS symbosl with a gap in between help improve frequency estimation which helps with better accuracy of pre-compensation. |
| QC | Similar to scheme1, we should discuss the QCL assumptions between the TRS/CSI-RS and SSB reference RS. |
| Ericsson | UE reporting Doppler frequency is an important issue to be discussed, without UE reporting Doppler the TRP based pre-compensation is incomplete. |
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## SFN transmission of PDCCH

### Issue #3-1 (Remaining FFS issues)

In RAN1#104b-e meeting several issues related to support of enhanced SFN PDCCH transmission were agreed for further study. Several companies provided their preference regarding these FFS issues. Based on the discussion, the following proposal is made:

**Issue #3-1:**

* In CA scenario additionally support RRC configured set of the serving cells which can be addressed by a single MAC CE
  + **Supported**: Qualcomm, Lenovo/MotMobility, Docomo …
  + **Not supported**: …
* Enhanced MAC CE signaling is applicable to a CORESET configured with CORESETPoolindex
  + **Supported**: …
  + **Not supported**: Qualcomm, Nokia/NSB, Lenovo/MotMobility , OPPO, MediaTek, Ericsson, LGE, CATT, Samsung, …
* For a CORESET that is RRC-configured with only two TCI states, the UE assumes that the DM-RS antenna port associated with PDCCH receptions in the CORESET are QCLed with the DL RSs in the two TCI states
  + **Supported**: Qualcomm, Doccomo
  + **Not supported**: Lenovo/MotM, Ericsson, Xiaomi, Samsung, Huawei/HiSilicon

#### Round-1

Companies are invited to provide their preference on the proposals above.

**Proposal #3-1:**

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| **Company** | **Comment** |
| InterDigital | We can discuss this later. |
| OPPO | As in our contribution, we don’t support the enhanced MAC CE signaling to be applied to a CORESET configured with *CORESETPoolindex*. |
| vivo | Discuss it later. |
| Nokia/NSB | For CA, though we don’t have strong view, sending multiple MAC-CEs for multiple CCs doesn’t require much overhead.  For applicability to M-DCI M-TRP, we don’t see the use case. |
| MediaTek | Do not support the second bullet (Enhanced MAC CE signaling)  For other proposals, need more discussion |
| Lenovo/MotM | For the third bullet, if only two TCI states are configured, beam switching would be in RRC level and we are not sure it is a typical configuration for HST scenario |
| Apple | Discuss it later |
| Ericsson | 1. For CA related signaling, we can discuss it later. 2. PDCCH SFN is for sDCI based scheduling only, don’t support for CORESETs configured with CORESETPoolIndex 3. In our view, MAC CE activation is still needed even if only two TCI states are configured for a CORESET as the CORESET could still be activated with one TCI state. |
| Xiaomi | For the third bullet, we share same view as Lenovo/MotM. |
| Docomo | 1. We are supportive for single MAC CE to update TCI states across CCs, to save MAC CE overhead. 2. In Rel.16, if CORESETPoolIndex is configured to a CORESET, other CORESETs without CORESETPoolIndex were assumed CORESETPoolIndex = 0 is configured. We are wondering which the intention of OPPO’s comment is.  * Alt1: when CORESETPoolIndex is configured by RRC, no CORESET can be activated with two TCI states in the same CC. * Alt2: when CORESETPoolIndex is configured by RRC, for the CORESET not configured with CORESETPoolIndex, it is still possible to activate it with two TCI states.  1. Support SFN CORESET by RRC configuration without MAC CE. |
| LG | For the second bullet, we also prefer ‘Not supported’. |
| CATT | 1. TCI states of a list of serving cells can be updated with a single MAC CE in current spec, so similar mechanism can be reused. 2. We don’t see the need of considering SFN enhancement for M-DCI*.* 3. The last issue is associated with switching of S-TRP and M-TRP. If a CORESET is RRC-configured with two TCI states, S-TRP can still be enabled by MAC-CE command. |
| Samsung | 1st issue: We tend to agree with the proposal.  2nd issue: We do not support activating two TCI states for CORESETs configured with coresetPoolIndex as each CORESET with a certain coresetPoolIndex.  3rd issue: Same view with Ericsson. Although only two TCI states are configured, only a single TCI can be activated for the CORESET.  Also, regarding 1st issue, we can agree with discussing above issues later. |
| Huawei, HiSilicon | We can further discuss these issues later.  For the third issue, we have agreed to use MAC CE to activate two TCI states, which has been informed to RAN2 also, but the wording in issue 3 is implying that this is by RRC configuration. |
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#### Round-2

Companies are invited to provide their preference on the proposals above.

**Proposal #3-1 (for conclusion):**

* Enhanced MAC CE signaling is not applicable to a CORESET configured with CORESETPoolindex

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| **Company** | **Comment** |
| Moderator | It would be beneficial to make the above conclusion to simplify the discussion on default beam focusing on single DCI case. |
| Samsung | Support the conclusion. |
| Docomo | Could you clarify which the intention of the proposal is?   * Alt1: when CORESETPoolIndex is configured for a CORESET in a CC by RRC, no other CORESET can be activated with two TCI states in the same CC. * Alt2: when CORESETPoolIndex is configured for a CORESET in a CC by RRC, for the CORESET not configured with CORESETPoolIndex, it is still possible to activate two TCI states.   The question is because, in Rel.16, if CORESETPoolIndex is configured to a CORESET, other CORESETs without CORESETPoolIndex were assumed CORESETPoolIndex = 0 is configured.  The proposals looks like Alt.2, but Alt.1 is more consistent with M-DCI in Rel.16. |
| QC | Support. |
| Xiaomi | It is better to clarify that Whether Alt 1 or Alt 2 proposed from DOCOMO is the intention of the conclusion. |
| Ericsson | Support |
| LG | Support the proposal. And Alt1 proposed by DOCOMO is aligned with our understanding. |
| CATT | Support |
| OPPO | Regarding DOCOMO’s question, we prefer Alt1 and propose to update the conclusion as:  Enhanced MAC CE signaling is not applicable to all the configured CORESETs in a BWP if at least one of the CORESETs is configured with *CORESETPoolindex* in the BWP. |
| vivo | Fine with OPPO’s revision. |
| MediaTek | Support |
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### Issue #3-2 (Identification of SFN PDCCH transmission)

Several companies have mentioned the issue of identification of the Rel-17 enhanced SFN PDCCH transmission scheme (i.e., scheme 1 and TRP-based pre-compensation).

**Issue #3-2:**

* Enhanced SFN PDCCH transmission scheme (scheme 1 and TRP-based pre-compensation) is identified by
  + **Alt 1a**: RRC parameter and number of TCI states, where RRC parameter is defined for PDCCH only
    - **Supported by**: Qualcomm, Intel, ZTE, Samsung,
  + **Alt 1b**: RRC parameter and number of TCI states, where RRC parameter is the same as used for identification of scheme 1 or TRP based pre-compensation for PDSCH
    - **Supported by**: vivo, …
  + **Alt 2**: Number of TCI states
    - **Supported by**: vivo, Ericsson, Convida Wireless, Sony, Docomo, LGE, CATT, NEC, Hauwei/HiSilicon
  + FFS other details including whether RRC parameter is common or separate between scheme 1 and TRP-based pre-compensation schemes

#### Round-1

Companies are invited to provide their views regarding the above options.

**Proposal #3-2:**

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| **Company** | **Comment** |
| InterDigital | We can discuss this later. |
| QC | Similar to scheme 1 (PDSCH), RRC parameter is needed such that the UE is prepared for the advanced tracking and demod of PDCCH. Also, this gives the network the flexibility to apply scheme-1 independently for PDCCH and PDSCH.  If single RRC parameter used for indication of scheme-1 both PDSCH, then this parameter should be defined per-CC and NW should always use scheme1 for both PDCCH and PDSCH (for UEs that don’t support dynamic switching to sTRP). |
| OPPO | It should be clarified firstly for Alt 1a/1b that: If a PDCCH is configured with SFN transmission by RRC, can the corresponding CORESET be configured with single TCI state? |
| ZTE | Support Alt 1a for more flexibility |
| vivo | Support Alt 2.  If one CORESET is configured with SFN scheme by RRC, while another CORESET is configured with STRP scheme by RRC or CORESET0 from STRP, UE still should switch the receiving process between SFN and STRP scheme. Therefore, the RRC parameter for SFN PDCCH can’t provide more time for UE to prepare its receiving process than MAC CE. On the contrary, using MAC CE with 2 TCI states as the indication is a more feasible way for scheduling. |
| Nokia/NSB | We see the following use cases are valid (yellow parts are scope of this AI)   * RRC parameter should be designed by RAN2 with the following consideration * Switching without RRC configuration is not supported as agreed for PDSCH.  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | PDSCH | | | | | PDCCH |  | Rel-15 | Rel-16 | Scheme 1 | Pre-compensation | | Rel-15 | O | O | O | O | | Rel-17 URLLC | O | O | FFS | FFS | | Scheme 1 | FFS | FFS | O | X | | Pre-compensation | FFS | FFS | X | O | |
| Lenovo/MotM | We should first make a decision on whether common signaling is used for identifying Rel-17 enhanced SFN transmission scheme for PDSCH and PDCCH, i.e. scheme 1 and TRP-based pre-compensation. |
| Apple | The solution can be similar for PDSCH and PDCCH. But maybe it is too early to discuss it. |
| Ericsson | Support indicating SFN PDCCH by the number of activated TCI states for a CORESET.  For mTRP PDSCH scheme 1a in Rel-16, there is no dedicated RRC configuration and it is indicated solely by associating a TCI codepoint with 2 TCI states. We don’t think see why different methodologies should be used here for PDCCH SFN. RRC configuration for Scheme 1 is mainly to differentiate between legacy schemes as it cannot be indicated by number of TCI states only. |
| Convida Wireless | Support Alt 2. |
| Xiaomi | We want to clarify that if two TCI states are activated for a CORESET, does it mean that two TCI states are activated for all SS sets associated with this CORESET? |
| Sony | Support Alt 2.  Like Ericsson mentioned, 2 TCI states activated for a CORESET would implicitly indicate UE that this is SFN PDCCH transmission, therefore no need for redundant RRC configuration.  In addition, in SFN Scheme 1, PDCCH and PDSCH are transmitted in SFN manner and we believe in real-life deployment both are transmitted in the same way, i.e. either in SFN or from S-TRP. |
| Docomo | Since CORESET with two TCI state happens only for SFN PDCCH, we think Alt.2 is fine. But, we prefer to discuss this later. |
| LG | We also prefer Alt2. MAC CE enhancement for activating two TCI states already agreed, and SFN PDCCH transmission can be identified based on that MAC CE. |
| CATT | Support Alt 2. |
| NEC | We prefer Alt 2. |
| Samsung | Support Alt.1a. For PDCCH SFN, at least a RRC parameter is needed to differentiate the scheme 1 and TRP pre-compensation scheme. We can tend to agree with the intention of the Alt.2 but not sure how to distinguish scheme 1 and TRP pre-compensation. |
| Huawei, HiSilicon | We prefer Alt. 2 at this stage. However, this discussion may depends on decisions of previous issues, such as 3-1. |

#### Round-2

Companies are invited to provide their views regarding the above options.

**Proposal #3-2:**

* TBD

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| **Company** | **Comment** |
| Moderator | Please continue discussion trying to address questions from Samsung, Xiaomi and Ericsson. |
| QC | Support Alt 1a. |
| CATT | Alt 2 is supported for scheme 1; Alt 1a is supported for TRP-based pre-compensation. |
| OPPO | We have a question for clarification on Alt 1a/1b: If a PDCCH is configured with SFN transmission by RRC, can the corresponding CORESET be configured with single TCI state, or it can only be configured with two TCI states? |
| vivo | To Samsung: In our PDCCH/PDSCH should be pre-compensated simultaneously, thus a common RRC parameter can be used for both PDCCH/PDSCH pre-compensation, but not only defined for PDCCH.  To Xiaomi: In our understanding, if two TCI states are activated for a CORESET, whether SS sets are activated by one or both of two TCI states can be further discussed. SS sets activated by one or two TCI states of the CORESET can bring the feasibility in some cases, as shown in section 2.4.2 in our contribution R1-2104346. But if the CORESET is configured by a specific RRC parameter like ‘*sfnscheme*’, we believe the CORESET and all associated SS sets would be activated with two TCI states logically.  To OPPO: In our understanding, it can only be configured with two TCI states, if a PDCCH is configured with SFN transmission by RRC. |
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### Issue #3-3 (Default TCI for single-beam PDSCH)

Regarding default beam assumption for PDSCH reception. When two TCI states are indicated for CORESET, several companies proposed to enhance rule(s) to determine default beam (TCI state) for PDSCH reception. In particular, whether and which default TCI state should be used for Rel-15 single-TRP and Rel-16 scheme 3/4 PDSCH reception. Based on the company’s contributions the following alternatives were identified.

#### Round-1

**Issue #3-3:**

* If a CORESET is indicated with two TCI states and time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*
  + **Alt 1:** New rule(s) to determine one of the TCI states of the CORESET as default beam for Rel-15 single-TRP and Rel-16 scheme 3/4 PDSCH reception is supported
  + If neither of *enableDefaultTCIStatePerCoresetPoolIndex* and *enableTwoDefaultTCI-States* is configured down-select one alternative
    - **Alt 1-1**: gNB ensures the lowest CORESET ID in the latest slot only configured one TCI state by implementation
    - **Alt 1-2**: Modify the definition of the lowest CORESET ID in the latest slot, e.g. the lowest CORESET ID among the CORESETs associated with one TCI state in the latest slot.
    - **Alt 1-3**: QCL assumption associated with one of TCI states, e.g. always selects the first or the second TCI state or the TCI state with a lower ID
    - **Supported by**: vivo, Xiaomi, ZTE, Ericsson, Qualcomm, Spreadtrum, CATT, Convida Wireless, …
  + **Alt 2:** The default TCI state for Rel-15 single-TRP and Rel-16 scheme 3/4 PDSCH is not specified / supported
    - **Supported by**: Nokia/NSB, Intel, …

Based on the companies view the following proposal is made.

**Proposal #3-3:**

* If a CORESET is indicated with two TCI states and time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*
  + If neither of *enableDefaultTCIStatePerCoresetPoolIndex* and *enableTwoDefaultTCI-States* is configured down-select one alternative
    - **Alt 1-1**: gNB ensures the lowest CORESET ID in the latest slot only configured one TCI state by implementation
    - **Alt 1-2**: Modify the definition of the lowest CORESET ID in the latest slot, e.g. the lowest CORESET ID among the CORESETs associated with one TCI state in the latest slot.
    - **Alt 1-3**: QCL assumption associated with one of TCI states, e.g., always selects the first or the second TCI state or the TCI state with a lower ID
    - **Alt 1**-4: QCL assumption associated with one of two TCI states, e.g. selects either the first or the second TCI state or the TCI state of the lowest CORESET ID

Companies are invited to provide their views regarding the above options.

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| **Company** | **Comment** |
| InterDigital | Support FL proposal, preferring Alt 1-3 or 1-1. |
| QC | Deprioritize the discussion of this topic |
| OPPO | For a UE without capability of dynamic switching between S-TRP and SFN transmission, the following cases cannot be supported when RRC configures SFN transmission for PDSCH:   * Case 1: Single default TCI state for case of smaller than threshold, while SFN transmission with two TCI states indicated by TCI field for case of equal to or larger than threshold. * Case 2: For case of equal to or larger than threshold, no TCI field in PDCCH1 (with single TCI state) scheduling PDSCH1, while SFN transmission with two TCI states indicated by TCI field in PDCCH2.   Considering this, our proposal is:  Proposal: For a UE configured with SFN transmission (scheme 1 or TRP-based pre-compensation), if *enableTwoDefaultTCI-States* is not configured, the time offset between the reception of the DL DCI and the corresponding PDSCH should be equal to or larger than the threshold *timeDurationForQCL.* |
| ZTE | Support the proposal |
| vivo | Support the proposal |
| Nokia/NSB | Though we don’t see the use case, if supported, we added Alt 1-4, and prefer Alt 1-4. |
| MediaTek | Support the proposal. Prefer Alt 1-1 |
| Lenovo/MotM | Support FL proposal. Prefer Alt 1-2 or 1-3. |
| Apple | Discuss later.  Default beam, no matter which flavor it is, it is typically based on MAC-CE  We have the same companies arguing that they wanted to have DCI based QCL indications. Then, they also wanted default beam which is MAC-CE based.  This is very conflicting for our product implementation.  If default TCI is ever discussed, the first thing we need is to agree that it is UE optional. |
| Ericsson | We support the proposal |
| Convida Wireless | Support, prefer 1-3. |
| Xiaomi | We suggest to change Alt 1-3 as follows:  QCL assumption associated with one TCI state of the lowest CORESET ID in the latest slot, if there are two activated TCI states for the CORESET with the lowest CORESET ID, one of two TCI states will be selected, e.g. always selects the first or the second TCI state or the TCI state with a lower ID. |
| Spreadtrum | Support |
| Docomo | Support, and prefer Alt 1-3. |
| LG | Support FL’s proposal, and Alt 1-3 is preferred. |
| CATT | Alt 1-3 is preferred. Alt 1-1 too restrictive to NW. |
| NEC | Support the proposal. |
| Samsung | Support FL proposal except Alt.1-1 due to the unnecessary restriction. We are also okay with discussing this issue later. |

#### Round-2

**Proposal #3-3a:**

* If a CORESET is indicated with two TCI states and time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*
  + If ~~neither of~~ *~~enableDefaultTCIStatePerCoresetPoolIndex~~* ~~and~~ *enableTwoDefaultTCI-States* is not configured down-select one alternative
    - **Alt 1-1**: gNB ensures the lowest CORESET ID in the latest slot only configured one TCI state by implementation
    - **Alt 1-2**: Modify the definition of the lowest CORESET ID in the latest slot, e.g. the lowest CORESET ID among the CORESETs associated with one TCI state in the latest slot.
    - **Alt 1-3**: QCL assumption associated with one of TCI states, e.g., always selects the first or the second TCI state or the TCI state with a lower ID
    - **Alt 1-4**: QCL assumption associated with one of two TCI states, e.g. selects either the first or the second TCI state or the TCI state of the lowest CORESET ID
  + FFS whether it is optional feature

Companies are invited to provide their views regarding the above options.

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| **Company** | **Comment** |
| Moderator | The proposal seems acceptable for most of the companies. The proposal 3-3 was modified to 3-3a to accommodate comments from Nokia and Apple. Please note that the wording of the proposal may need to be modified depending on the conclusion for other issues (e.g. 3-2) |
| Samsung | Support in principle. |
| ZTE | Can we make Alt 1-3 and 1-4 clearer ?  In my opinion, Alt 1-4 is  Alt1-3: QCL assumption associated with one of two TCI states, e.g. selects either the first or the second TCI state or the TCI state of the lowest CORESET ID in the latest slot  Alt 1-3 seems not clear, selects the first or the second TCI state or the TCI state with a lower ID from which CORSETs/TCI state pool? |
| Docomo | Support. Agree with ZTE’s revision. |
| QC | It is not clear what is the use case. For clarification, is this discussion solely for UE supporting dynamic switching to single TRP? |
| Xiaomi | We have same concern with ZTE. Alt 1-3 and Alt 1-4, and the difference between these two are not clear.  And we suggest to change Alt 1-3 as follows:  Alt 1-3: QCL assumption associated with one TCI state of the lowest CORESET ID in the latest slot, if there are two activated TCI states for the CORESET with the lowest CORESET ID, one of two TCI states will be selected, e.g. always selects the first or the second TCI state or the TCI state with a lower ID. |
| Ericsson | We may all assume the *enableTwoDefaultTCI-States* is reused in Rel-17 as in Rel-16, shall we clarify that? |
| LG | Support XIaomi’s revision for the clarification. In addition, to make clear, the following modification can be added.  “Alt 1-3: QCL assumption associated with one TCI state of the lowest CORESET ID in the latest slot, if there are two activated TCI states for the CORESET with the lowest CORESET ID and UE is not configured with Rel-17 Scheme 1 or pre-compensation scheme for PDSCH, one of two TCI states will be selected, e.g. always selects the first or the second TCI state or the TCI state with a lower ID.” |
| CATT | Support Alt 1-3. |
| OPPO | We think the proposal can only be applied to the case that SFN transmission for PDSCH is not configured.  From some companies’ understanding, SFN for PDCCH and PDSCH should be configured together. However, for a UE without capability of dynamic switching between S-TRP and SFN transmission, the following case cannot be supported when RRC configures SFN transmission for PDSCH:   * Single default TCI state for case of smaller than threshold, while SFN transmission with two TCI states indicated by TCI field for case of equal to or larger than threshold.   Hence, the proposal should be:   * If a CORESET is indicated with two TCI states and time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*   + If ~~neither of~~ *~~enableDefaultTCIStatePerCoresetPoolIndex~~* ~~and~~ SFN transmission for PDSCH and *enableTwoDefaultTCI-States* is not configured down-select one alternative   (…)  Furthermore, we need to clarify that for a UE configured with SFN transmission (scheme 1 or TRP-based pre-compensation) for PDSCH, if enableTwoDefaultTCI-States is not configured, the time offset between the reception of the DL DCI and the corresponding PDSCH should be equal to or larger than the threshold timeDurationForQCL. |

### Issue #3-4 (Default TCI for Rel-17 SFN PDSCH)

Several companies have proposed to define new rule for determination of default TCI states for reception of Rel-17 enhanced SFN PDSCH, when PDSCH is scheduled by PDCCH transmitted from CORESET indicated with two TCI states. Based on the company’s contributions the following alternatives were identified.

#### Round-1

**Proposal #3-4:**

* If a CORESET is indicated with two TCI states and UE is configured with *enableTwoDefaultTCI-States* and time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*, the following rule is used to determine default beam(s) for Rel-17 SFN PDSCH reception:
  + **Alt 1**: Reuse rule to determine TCI states as defined for Rel-16 PDSCH scheme-1a
  + **Alt 2**: Introduce new rules to determine TCI states based on two TCI state(s) of the CORESET
    - FFS other details

**Proposal #3-4a:**

* If a CORESET is indicated with two TCI states and UE is configured with Rel-17 *Scheme 1 or pre-compensation scheme* and time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*,
  + UE assumes that the DM-RS ports of PDSCH are quasi co-located with the RS(s) with respect to the QCL parameter(s) used for PDCCH of the CORESET associated with the lowest CORESET ID in the latest slot.

Companies are invited to provide their views regarding the above options.

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| **Company** | **Comment** |
| InterDigital | Support FL proposal, preferring Alt1. |
| QC | Support FL proposal. |
| OPPO | Alt 1 is preferred. We don’t think there is any specification impact for Alt.1 |
| vivo | Support Alt 1. |
| Nokia/NSB | Support Alt 1 for proposal #3-4  Also, add Proposal #3-4a, which is for Rel-17 PDCCH and Rel-17 PDSCH. |
| MediaTek | Support the proposal. Prefer Alt 1 |
| Lenovo/MotM | Support Alt1 |
| Apple | We first need to agree that PDCCH and PDSCH have to have the same mode, i.e., do not have scheme 1 for PDCCH and then pre-compensation for PDSCH. Then we can discuss the default beam |
| Ericsson | Support the proposal with some modification, i.e., replacing ‘Rel-17 SFN PDSCH’ with ‘Scheme 1’ because default TCI state is only relevant to FR2, while gNB based pre-compensation was agreed only for FR1.  When Scheme 1 is configured, it is expected that the UE is capable of receiving from two beams simultaneously and thus automatically supports two default TCI states. To be consistent with Rel-16 mTRP, we slightly prefer Alt.1 |
| Convida Wireless | OK with both Proposal 3-4 and 3-4a. |
| Xiaomi | Support Proposal 3-4 |
| Sony | Support Alt.1. |
| Spreadtrum | Support |
| Docomo | Support the Proposal 3-4 and 3-4a. |
| LG | Support FL’s proposal, and Alt1 is preferred.  One question for clarification: If one of the solutions for proposal #3-3 is supported, then how to support proposal #3-4a? |
| CATT | Support Proposal #3-4a. |
| NEC | Support the proposals. |
| Samsung | Support Proposal 3-4 and prefer Alt.1. |

#### Round-2

**Proposal #3-4b:**

* If a CORESET is indicated with two TCI states and UE is configured with *enableTwoDefaultTCI-States* and time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*, the down-select rule used to determine default beam(s) for Rel-17 SFN PDSCH reception:
  + **Alt 1**: Reuse rule to determine TCI states as defined for Rel-16 PDSCH scheme-1a
  + **Alt 2**: Introduce new rules to determine TCI states based on two TCI state(s) of the CORESET
    - FFS other details
* If a CORESET is indicated with two TCI states and UE is configured with Rel-17 *Scheme 1 or pre-compensation scheme* and time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*,
  + UE assumes that the DM-RS ports of PDSCH are quasi co-located with the RS(s) with respect to the QCL parameter(s) used for PDCCH of the CORESET associated with the lowest CORESET ID in the latest slot.

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| **Company** | **Comment** |
| Moderator | Merged proposals 3-4 and 3-4b. Please note that the wording of the proposal may need to be modified depending on the conclusion for other issues (e.g. 3-2) |
| Samsung | We only support the first main bullet and the following sub-bullets, especially Alt.1. Regarding the second main bullet, should UE support two default beams when the CORESET with lowest ID has two TCI states although *enableTwoDefaultTCI-States* is not configured? |
| Docomo | Support |
| QC | Support the first bullet only. |
| Xiaomi | We only support the first main bullet and prefer Alt 1.  For the second main bullet, we have same question as Samsung. In addition, we think it is better to update it to that “…UE is configured with Rel-17 *Scheme 1 or pre-compensation scheme* for PDSCH…”. |
| Ericsson | As moderator pointed out the wording may need to adjust, we support the proposal in principle. |
| LG | Support in principle. Similar view with Ericsson. |
| CATT | It should be clarified that Proposal 3-4 and 3-4a are two alternatives. However, in current Proposal 3-4b, they are listed as two cases of one option.  In our opinion, 3-4(i.e., the first main bullet) is preferred. |
| OPPO | We only support the first bullet. |
| vivo | Support in principle |
| MediaTek | Support the first bullet only and prefer Alt 1. |

### Issue #3-5 (TCI states of PDSCH with absent TCI field)

Several companies discussed the issue of PDSCH reception when TCI field is not present in DCI scheduling PDSCH. Based on the discussion the following alternatives were identified for the following discussion.

#### Round-1

**Proposal #3-5**:

* For Rel-17 enhanced SFN PDSCH reception, when the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL*
  + **Alt 1:** Support configuration when there is no TCI field in the DCI scheduling PDSCH
  + **Alt 2:** Configuration when there is no TCI field in the DCI scheduling PDSCH is not supported

Companies are invited to provide their views regarding the above options.

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| **Company** | **Comment** |
| InterDigital | Alternatives are not clear to us. |
| OPPO | For a UE without capability of dynamic switching between S-TRP and SFN transmission, the following cases cannot be supported when RRC configures SFN transmission for PDSCH:   * Case 1: Single default TCI state for case of smaller than threshold, while SFN transmission with two TCI states indicated by TCI field for case of equal to or larger than threshold. * Case 2: For case of equal to or larger than threshold, no TCI field in PDCCH1 (with single TCI state) scheduling PDSCH1, while SFN transmission with two TCI states indicated by TCI field in PDCCH2.   Considering this, we support Alt 2. |
| ZTE | Support Alt2 |
| vivo | Support the proposal.  For Alt 1: If DCI without TCI field is transmitted in SFN manner, a UE without the capability of dynamic switching between S-TRP and SFN transmission can still work.  For Alt 2: It’s the same as the rule for R16 MTRP.  Slightly prefer Alt 1 due to the scheduling flexibility. |
| Nokia/NSB | To my understanding, this is asking if we define default TCI states by RRC, otherwise we don’t support the option (Alt 2).  This can be discussed later. |
| MediaTek | Support the proposal. Prefer Alt 2 |
| Lenovo/MotM | Support Alt1 |
| Apple | Prefer Alt2 |
| Ericsson | Prefer Alt.2.  For DCI format 1-0, there is no TCI field and should always be supported, thus it may be better to mention that the proposal is for DCI format 1\_1 and 1\_2. |
| Convida Wireless | Support Alt 1. |
| Xiaomi | Support the proposal. Prefer Alt 2. |
| Sony | For the fallback DL DCI, i.e. 1\_0, there is no TCI field. But we think it should be supported.  And for the default beam issue, is it a feasible solution to allow the scheduled PDSCH to follow the scheduling PDCCH in Rx beam-wise? |
| Spreadtrum | Alt2 |
| Docomo | Support Alt.1.  Please note that the minimum value of *timeDurationForQCL* is 14-symbol in 120 kHz SCS, which means DCI based beam indication is not used most of cases in practical in FR2. So, it is beneficial to turn off TCI state field to save DCI overhead, as same as Rel.15/16.  timeDurationForQCL SEQUENCE {  scs-60kHz ENUMERATED {s7, s14, s28} OPTIONAL,  scs-120kHz ENUMERATED {s14, s28} OPTIONAL |
| LG | Support Alt1 |
| CATT | Support Alt 1 and suggest to clarify that   * **Alt 1:** Support configuration when there is no TCI field in the DCI scheduling PDSCH * When the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold, but there is no TCI field in the DCI scheduling PDSCH,   + If a UE is configured with ‘*enableTwoDefaultTCI-States*’, UE applies the QCL assumption of the CORESET that schedules the PDSCH when receiving the PDSCH.   + If a UE is not configured with ‘*enableTwoDefaultTCI-States*’ and the CORESET that schedules the PDSCH is associated with two TCI states, UE applies the first TCI state of the CORESET when receiving the PDSCH. |
| Samsung | Support FL proposal and prefer Alt.1. |

#### Round-2

**Proposal #3-5a**:

* For Rel-17 enhanced SFN PDSCH reception scheduled by DCI format 1\_1 and 1\_2, when the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL* down-select one alternative
  + **Alt 1:** Support configuration when there is no TCI field in the DCI scheduling PDSCH
    - If a UE is configured with ‘*enableTwoDefaultTCI-States*’, UE applies the QCL assumption of the CORESET that schedules the PDSCH when receiving the PDSCH.
    - If a UE is not configured with ‘*enableTwoDefaultTCI-States*’ and the CORESET that schedules the PDSCH is associated with two TCI states, UE applies the first TCI state of the CORESET when receiving the PDSCH.
  + **Alt 2:** Configuration when there is no TCI field in the DCI scheduling PDSCH is not supported

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| **Company** | **Comment** |
| Moderator | The proposal is modified to #3-5a according to the comments above. |
| Samsung | Support Alt.1 from the proposal #3-5a. It seems that in the main bullet, there is no condition for the number of TCI states for scheduling CORESET. In that sense, regarding the first sub-bullet in Alt.1, UE can apply one or two QCL assumptions of the CORESET that schedules the PDSCH when receiving the PDSCH. Is it correct understanding? |
| Docomo | Support Alt.1 |
| QC | Support Alt 2. |
| Xiaomi | We have same concern as Samsung. And we suggest to update the first subbullet of Alt 1 to “if UE is configured with Rel-17 *Scheme 1 or pre-compensation scheme* and the CORESET that schedules the PDSCH is associated with two TCI states, UE applies the QCL assumption of the CORESET that schedules the PDSCH when receiving the PDSCH” |
| Ericsson | Support Alt 2. |
| LG | Support Alt1, but we do not need to consider enableTwoDefaultTCI-States because the time offset is equal or larger than threshold. |
| CATT | We have similar view as Samsung. So, the following revision of Proposal 3-5a is suggested.  **Proposal #3-5a**:   * For Rel-17 enhanced SFN PDSCH reception scheduled by DCI format 1\_1 and 1\_2, if a CORESET is indicated with two TCI states and the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL* down-select one alternative   + **Alt 1:** Support configuration when there is no TCI field in the DCI scheduling PDSCH     - If a UE is configured with ‘*enableTwoDefaultTCI-States*’, UE applies the QCL assumption of the CORESET that schedules the PDSCH when receiving the PDSCH.     - If a UE is not configured with ‘*enableTwoDefaultTCI-States*’ ~~and the CORESET that schedules the PDSCH is associated with two TCI states~~, UE applies the first TCI state of the CORESET when receiving the PDSCH.   + **Alt 2:** Configuration when there is no TCI field in the DCI scheduling PDSCH is not supported |
| OPPO | Support Alt 2. |
| vivo | Regarding the 2nd bullet of Alt1, it depends on whether UE supports the dynamic switching between SFN PDSCH and STRP PDSCH. If not, the 2nd bullet of Alt1 is incomplete.  Therefore, we would like to update the wording as follows.  **Proposal #3-5a**:   * For Rel-17 enhanced SFN PDSCH reception scheduled by DCI format 1\_1 and 1\_2, when the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL* down-select one alternative   + **Alt 1:** Support configuration when there is no TCI field in the DCI scheduling PDSCH     - If a UE is configured with ‘*enableTwoDefaultTCI-States*’, UE applies the QCL assumption of the CORESET that schedules the PDSCH when receiving the PDSCH, when UE supports the dynamic switching between SFN PDSCH and STRP PDSCH.     - If a UE is not configured with ‘*enableTwoDefaultTCI-States*’ and the CORESET that schedules the PDSCH is associated with two TCI states, UE applies the first TCI state of the CORESET when receiving the PDSCH, when UE supports the dynamic switching between SFN PDSCH and STRP PDSCH.   + **Alt 2:** Configuration when there is no TCI field in the DCI scheduling PDSCH is not supported |
| MediaTek | Support Alt 2 |

### Issue #3-6 (Default TCI for aperiodic CSI-RS)

Regarding default beam for aperiodic CSI-RS reception. Several companies proposed to define new rule to determine default beam for aperiodic CSI-RS reception in Rel-17, when CORESET is indicated with two TCI states. Based on the company’s contributions the following proposal is made.

#### Round-1

**Proposal #3-6:**

* If a CORESET is indicated with two TCI states, and scheduling offset for AP CSI-RS is less than the threshold and *enableTwoDefaultTCIStates* is not configured
  + If there is no other overlapping DL signal with indicated TCI state
    - Use one of two TCI states as default beam for aperiodic CSI-RS reception using the same principles as for default TCI state for Rel-15 single TRP PDSCH case
  + If there is other overlapping DL signal, the default TCI of the AP CSI-RS follows one TCI state of the other signal
    - FFS other details

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| **Company** | **Comment** |
| InterDigital | Support FL proposal |
| QC | Support in principle.   * When there is no other overlapping DL signal and each TCI state of the CORESET is associated with QCL-TypeD, the UE applies the first TCI state of the CORESET. * Otherwise, reuse Rel-16 rule where the UE applies the first TCI state of the two TCI states of the PDSCH (indicated with two TCI states) when receiving the aperiodic CSI-RS |
| OPPO | We think the current description in spec. for case that there is other overlapping DL signal is sufficient. No new conclusion is needed for that. We propose to delete the part for “If there is other overlapping DL signal,…”.  The first part is fine to us. |
| ZTE | Support in principle |
| vivo | Support |
| Nokia/NSB | Please find the following modification.  **Proposal #3-6:**   * If a CORESET is indicated with two TCI states, and scheduling offset for AP CSI-RS is less than the threshold and *enableTwoDefaultTCIStates* is not configured   + If there is no other overlapping DL signal having different QCL-TypeD with the indicated TCI state     - Use one of two TCI states as default beam for aperiodic CSI-RS reception using the same principles as for default TCI state for Rel-15 single TRP PDSCH case   + If there is other overlapping DL signal having different QCL-typeD with the indicated TCI states, the default TCI of the AP CSI-RS follows one TCI state of the other signal     - FFS other details |
| MediaTek | Support |
| Lenovo/MotM | Support FL proposal |
| Apple | gNB should provide explicit indication for the CSI-RS QCL  We do not support HST-SFN CSI-RS enhancement, but we support HST-SFN PDCCH/PDSCH, fundamentally, the default beam cannot work well in the field. |
| Ericsson | Support FL’s proposal |
| Convida Wireless | Support in principle, but suggest to explicitly write out the “principles from default TCI state for Rel-15 single TRP PDSCH case”. Does this case include a principle to select one of two TCI states? |
| Xiaomi | Support FL proposal |
| Spreadtrum | Fine |
| Docomo | Support. |
| LG | Support the proposal |
| CATT | Support FL proposal |
| Samsung | Support in principle |

#### Round-2

**Proposal #3-6a:**

* If a CORESET is indicated with two TCI states, and scheduling offset for AP CSI-RS is less than the threshold and *enableTwoDefaultTCIStates* is not configured
  + If there is no other overlapping DL signal having different QCL-TypeD with the indicated TCI state
    - Use one of two TCI states as default beam for aperiodic CSI-RS reception using the same principles as for default TCI state for Rel-15 single TRP PDSCH case
  + If there is other overlapping DL signal having different QCL-typeD with the indicated TCI states, the default TCI of the AP CSI-RS follows one TCI state of the other signal
    - FFS other details

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| **Company** | **Comment** |
| Moderator | The proposal was modified according to Nokia comment. Most of the companies are OK with the proposal.  Re Apple. Please clarify you view why default beam is not good solution. |
| Docomo | Support |
| QC | In the first sub-bullet discussing the no-overlap scenario, it is not clear to me why we need to mention that non-overlapping DL signal has two different QCL TypeD. Also, suggest the following edit.   * If a CORESET is indicated with two TCI states having different QCL-typeD, and scheduling offset for AP CSI-RS is less than the threshold and *enableTwoDefaultTCIStates* is not configured   + If there is no other overlapping DL signal ~~having different QCL-TypeD with the indicated TCI state~~     - Use one of two TCI states as default beam for aperiodic CSI-RS reception using the same principles as for default TCI state for Rel-15 single TRP PDSCH case   + If there is other overlapping DL signal having different QCL-typeD with the indicated TCI states, the default TCI of the AP CSI-RS follows one TCI state of the other signal |
| CATT | Support |
| OPPO | In current spec, the other DL signal doesn’t include CORESET. Hence, the enhancement of SFNed PDCCH has nothing to do with AP CSI-RS when there is other overlapping DL signal.  We propose to delete the part for “If there is other overlapping DL signal,…”. |
| MediaTek | Support |
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### Issue #3-7 (Default spatial / PL RS for single-TRP PUSCH/PUCCH/SRS)

In the context of supporting two TCI states for CORESET, several companies have mentioned the issue of default uplink beam(s) and PL-RS determination for dedicated-PUSCH/PUCCH/SRS transmission to a single TRP. Based on the company’s contributions the following proposal is made.

#### Round-1

**Proposal #3-7:**

* If a CORESET is indicated with two TCI states for PUSCH/PUCCH/SRS transmission to a single-TRP
  + If PL-RS and spatial relation information are not configured and default beam is enabled for the PUCCH transmission
    - For single-TRP PUCCH transmission define rule(s) to determine one of the TCI states of the CORESET used as default beam and PL RS
    - FFS the exact rule
  + If PUSCH scheduled by DCI format 0\_0 and default beam is enabled for the PUSCH transmission
    - For single-TRP PUSCH transmission define rule(s) to determine one of the TCI states of the CORESET used as default beam and PL RS
    - FFS the exact rule
  + If PL-RS and spatial relation information are not configured and default beam is enabled for the SRS transmission
    - Define rule(s) for mapping of TCI states from CORESET to SRS resource sets to determine default beam and PL-RS

Companies to provide their preference on the proposal above.

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| **Company** | **Comment** |
| InterDigital | We can discuss this later |
| QC | Prefer to discuss later after making progress for higher priority discussion. |
| OPPO | Discuss PDSCH and AP CSI-RS first. |
| vivo | Discuss it later |
| Nokia/NSB | Whether to support default spatial relation/PL-RS for single TRP UL transmission can be discussed later. |
| MediaTek | Need more discussion |
| Lenovo/MotM | Support FL proposal |
| Apple | Discuss later  gNB needs to configure the QCL in the explicit way, we hope we can minimize the discussion on the default beam discussion which is not a good solution at all. |
| Ericsson | We are fine with FL’s proposal |
| Xiaomi | Need more discussion |
| Docomo | Support FL proposal. |
| CATT | Discuss this later |
| Samsung | Support FL proposal and also fine with discussing later. |
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### Issue #3-8 (Default spatial / PL RS for Rel-17 multi-TRP PUSCH/PUCCH)

If a CORESET is indicated with two TCI states, several companies proposed to define rule to determine default beams for Rel-17 multi-TRP PUSCH/PUCCH transmission schemes with repetition. Based on the discussion the following proposal is made.

#### Round-1

**Proposal #3-8:**

* If a CORESET is indicated with two TCI states, support two TCI states of the CORESET used as default beams and PL RS for Rel-17 Multi-TRP PUSCH/PUCCH repetition scheme
  + FFS the exact rule

Companies to provide their views on the proposal above.

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| **Company** | **Comment** |
| InterDigital | We can discuss this later |
| QC | Prefer to discuss later after making progress for higher priority discussions. |
| OPPO | Discuss PDSCH and AP CSI-RS first. |
| vivo | Discuss it later |
| Nokia/NSB | We can consider the common solution with AI 8.1.2.1 |
| MediaTek | Need more discussion |
| Lenovo/MotM | Prefer to discuss later |
| Apple | Discussion later |
| Ericsson | We need to discuss first whether it is feasible or allowed for mTRP PUCCH/PUSCH without configuring two spatial relations/pathloss RSs. |
| Xiaomi | Need more discussion |
| Docomo | Support FL proposal. |
| CATT | Discuss this later |
| Samsung | Support FL proposal and also fine with discussing later. |
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### Issue #3-9 (PDCCH monitoring with different QCL-TypeD)

Several companies proposed to discuss priority rules for PDCCH monitoring of PDCCH candidates in overlapping monitoring occasion with different QCL-TypeD when CORESET is indicated with two TCI states. Based on the discussion the following proposal is made.

#### Round-1

**Proposal #3-9:**

* When a CORESET is activated with two TCI states which overlaps with other CORESET, support new prioritization rule for PDCCH monitoring of PDCCH candidates in overlapping monitoring occasion with different QCL-TypeD
  + **Alt 1**: Prioritization rule considers only CORESETs indicated with same number of TCI states (e.g., 2)
  + **Alt 2**: Prioritization rule considers CORESETs indicated with the same and different number of TCI states
  + FFS other details including whether new RRC parameter is required to indicate PDCCH monitoring assumptions using single TCI state or up to two TCI states

Companies to provide their views on the proposal above.

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| **Company** | **Comment** |
| Moderator | More inputs are required |
| InterDigital | We can discuss this later |
| QC | Support Alt 1. |
| OPPO | In Rel-16, there is no enhancement to support reception of two PDCCHs with different TCI states. It is not reasonable to support this feature only for SFNed CORESET. Hence, we propose to reuse the Rel-15 rule, and only reception of PDCCHs with the same TCI state(s) (including number) is supported regardless of the number of TCI states. |
| vivo | Discuss it later |
| Nokia/NSB | We can discuss this later |
| MediaTek | Need more discussion |
| Lenovo/MotM | Support Alt 2 since it provides flexibility for monitoring CORESET with one or two TCI states |
| Apple | Discuss later. Or the current spec is not broken. gNB should avoid the conflict of CORESET configuration exceeding UE capability |
| Ericsson | We are fine with the proposal. Alt.2 is preferred which can be based on the priority of the associated search space sets |
| Xiaomi | Support the proposal and we prefer Alt 2 for flexibility. |
| Spreadtrum | Support, Alt.2 is preferred. |
| Docomo | Support. In Rel-15/16, if PDCCH candidates in overlapping PDCCH monitoring occasions in multiple CORERSETs have different QCL-TypeD, UE monitors PDCCH only in a CORESET having the same QCL-TypeD as the CORESET determined from the priority rule that CSS has higher priority than USS and SS set with lower index has higher priority. If a CORESET can be activated with two TCI states, the rule for PDCCH monitoring in multiple CORESETs with different QCL-TypeD needs to be studied. |
| LG | Fine with the proposal |
| CATT | Alt 2 is preferred for flexibility. |
| NEC | Support the proposal. |
| Samsung | Support Alt.2. |

## Other issues

This section contains other issues the companies want to highlight for discussion regarding support of SFN PDCCH transmission.

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| **Company** | **Comment** |
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## Beam Failure Detection and Recovery

### Issue #4-1 (Configuration of RS for BFD)

Several companies have discussed the issue of reference signals configuration for beam failure detection (BFD), when two TCI states are activated for CORESET. Based on the company’s contributions the following alternatives were proposed.

**Issue #4-1:**

* When two TCI states are activated for a CORESET, support the following configuration of RS for BFD
  + Implicit configuration
    - **Alt 1-1**: RS of CORESETs with only single TCI states are used
      * **Supported by**: …
    - **Alt 1-2**: RS of CORESETs with both single and two TCI states are used
      * **Supported by (8)**: Lenovo/MotMobility, Nokia/NSB, Ericsson, Xiaomi, Convida Wireless, Sony, Docomo, CATT
    - **Alt 1-3**: RS of CORESETs with only two TCI states are used
      * **Supported by (3)**: Qualcomm, LG, CATT
  + Explicit configuration
    - **Alt 2-1**: Support defining CSI-RS resource or SSB pairs as BFD RS
      * FFS other details
      * **Supported by (4)**: NEC, Xiaomi, Lenovo/MotM, Sony
    - **Alt 2-2**: Reuse the existing Rel-15/Rel-16 approach for BFD RS configuration
      * **Supported by (9)**: Qualcomm, Nokia/NSB, Lenovo/MotMobility, OPPO, Ericsson, Convida Wireless, Docomo, LG, CATT …

Companies are invited to provide their views regarding the above alternatives.

#### Round-1

**Proposal #4-1:**

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs are required |
| InterDigital | We can discuss this later |
| QC | For implicit configuration, support Alt 1-3 since the two RSs are associated with the two different TRP and will provide proper indication on the BFD for each link. For explicit configuration, support Alt 2-2 as gNB is aware which link is more important to monitor and also to minimize spec impact given the limited time. |
| OPPO | Support Alt 2-2. |
| Nokia/NSB | BFD-RSs should be any RSs of any CORESET for detecting BFR. For SFN PDCCH, if one of beams is reachable, this doesn’t need BFR triggering.  If two CORESETs having one and two TCI states, BFR should be triggered if all CORESETs are failed. |
| Lenovo/MotM | For explicit configuration, we support Alt. 2-1. For implicit configuration, we support Alt 1-3 as first choice since RS of CORESETs with two states can be naturally used for BFD detection. Considering configuration flexibility, we are also fine with RS of multiple CORESETs with only single TCI state, hence we are also fine with Alt 1-2 as a second choice |
| Apple | Discuss later |
| Ericsson | Support Alt.1-2 for implicit, and Alt. 2-2 for explicit.  Suggest to revise the main bullet to something like:  **Issue #4-1:**   * When two TCI states are activated for at least one CORESET, support the following configuration of RS for BFD |
| Convida Wireless | Support 1-2. Support 2-2 as well, but I guess we could include Rel-17 BFD-RS configuration as well. |
| Xiaomi | Support Alt 1-2 for implicit and Alt 2-1 for explicit. |
| Sony | Support Alt1-2 and Alt 2-1. |
| Docomo | Support Alt 1-2 for implicit and Alt 2-2 for explicit. |
| LG | Support Alt1-3 for implicit, and Alt2-2 for explicit. |
| CATT | This issue can be discussed after BFR framework is agreed.  For implicit configuration, CORESETs with both single and two TCI states can be used, but CORESETs with two TCI states should have higher priority. Therefore, both Alt 1-2 and Alt 1-3 are acceptable.  For explicit configuration, Alt 2-2 is preferred. Besides, explicit configuration in Rel-17 BFR cannot be precluded at this stage. |
| NEC | We share similar view as Convida that Rel-17 TRP specific BFR needs to be included as well. For SFN PDCCH, if one TRP failed, the failed link can be recovered to resume SFN transmission.  It’s better to clarify whether the discussion is based on Rel-15/16 cell-specific BFR or Rel-17 TRP-specific BFR. It seems current discussion is only based on cell-specific BFR? If so, we are OK to discuss this firstly.   * For cell-specific BFR, w~~W~~hen two TCI states are activated for a CORESET, support the following configuration of RS for BFD * FFS: TRP-specific BFR. |
| Huawei, HiSilicon | We don’t the need to enhance the BFD/BFR, as with HST-SFN, the performance in terms of reliability and throughput has been improved, the failure cases have been reduced significantly. There’s no necessity to discuss it. |
| Moderator | Re Huawei. This enhancement is targeting both URRLC and HST-SFN scenarios.  Re NEC: This question is related to issue #4-4 |

#### Round-2

**Proposal #4-1:**

* When two TCI states are activated for a CORESET, support the following configuration of RS for BFD
  + Down-select one alternative for implicit configuration
    - **Alt 1-2**: RS of CORESETs with both single and two TCI states are used
    - **Alt 1-3**: RS of CORESETs with only two TCI states are used
  + Down-select one alternative for explicit configuration
    - **Alt 2-1**: Support defining CSI-RS resource or SSB pairs as BFD RS
      * FFS other details
    - **Alt 2-2**: Reuse the existing Rel-15/Rel-16 approach for BFD RS configuration

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| **Company** | **Comment** |
| Samsung | Support Alt.1-2 and Alt.2-2. |
| ZTE | Support |
| NEC | We still think the discussion of BFD RS should be separate for Rel-15/16 cell specific BFR and Rel-17 TRP specific BFR. As in Rel-15/16 cell specific BFR, there is one BFD RS set, and in Rel-17 TRP specific BFR, there are two BFD RS sets, the association and derivation of BFD RS set with the CORESET may be different, which is similar with designing of NBI RS set in Issue 4-3. |
| Docomo | Support Alt 1-2 for implicit and Alt 2-2 for explicit. |
| QC | Support FL proposal. Prefer Alt 1-3 for implicit and Alt 2-2 for explicit. |
| Xiaomi | Support the Proposal, and prefer Alt 1-2 and Alt 2-1. With Alt 2-2, the BFD RS only refer to one TRP for TRP specific BFD. It is possible that beam failure is detected but the radio link of SFN PDCCH is still workable, which will introduce some redundant BFR. |
| Ericsson | Alt 1-2 and Alt 2-2.  The main bullet should be updated:   * When two TCI states are activated for at least one ~~a~~ CORESET, support the following configuration of RS for BFD |
| LG | Support the proposal. And Alt1-3 and Alt2-2 are preferred. |
| CATT | Support FL’s proposal. |
| OPPO . | Support Alt 1-2 and Alt 2-2 |
| vivo | Support FL’s proposal. Considering the priority, a down-selection can be made in the next meeting. |
| MediaTek | Support Alt 1-3 and Alt 2-2 |

### Issue #4-2 (Hypothetical BLER calculation for BFD)

Several companies have discussed the issue of hypothetical BLER calculation using measurements from beam failure detection (BFD) RS, when two TCI states are activated for CORESET. Based on the company’s contributions the following alternatives were proposed.

**Issue #4-2:**

* When two TCI states are activated for a CORESET, hypothetical BLER for BFD calculated as follows
  + **Alt 3-1**: UE calculates hypothetical BLER using BFD RS assuming single-TRP transmission
    - **Supported by (3)**:, Ericsson, Convida Wireless, Huawei / HiSilicon …
  + **Alt 3-2**: UE calculates hypothetical BLER using BFD RS pairs assuming SFN transmission for multiple-TRPs
    - **Supported by (13)**: Qualcomm, NEC, Lenovo/MotMobility, LG, Nokia/NSB, vivo, Mediatek, Lenovo/MotM, Apple, Ericsson, Xiaomi , Sony , Docomo …

Companies are invited to provide their views regarding the above alternatives.

#### Round-1

**Proposal #4-2:**

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs are required |
| InterDigital | We can discuss this later |
| QC | Support Alt 3-2 where single SFN BLER is computed based on UE implementation. |
| vivo | Support Alt 3-2. |
| Nokia/NSB | Support Alt 3-2. |
| MediaTek | Support Alt 3-2 |
| Lenovo/MotM | Support Alt 3-2 to help matching with link quality for enhanced PDCCH transmission for HST |
| Apple | Alt 3-2 assumes certain BFD RS configuration, i.e., pair of RS is configured for BFD. We need to first agree on that. |
| Ericsson | Support Alt. 3-2 for a RS pair associated with one CORESET |
| Convida Wireless | Support Alt 3-1.  We don’t see a strong motivation to enhance this. If at least one BFD-RS is good enough, both Alt 3-1 and Alt 3-2 will not result in beam failure. If all BFD-RS are in outage, both Alt 3-1 and Alt 3-2 will result in beam failure. |
| Xiaomi | Support Alt 3-2 |
| Sony | Support Alt3-2. |
| Docomo | Support Alt. 3-2. Since PDCCH reception is SFN, hypothetical BLER should be also calculated by SFN. |
| LG | Support Alt 3-2. |
| CATT | This issue can be discussed later.  Alt 3-2 is an optimization on existing hypothetical BLER calculation. If both PDCCH and PDSCH are configured with SFN operation, this alternative can work well.  If PDSCH is not configured with SFN (e.g. PDSCH scheme 3), SFN-specific hypothetical BLER calculation may not be accurate. There might be a case that failure report is not triggered but PDSCH cannot be decoded correctly (assuming that TCI states of PDCCH and PDSCH are same). In this case, existing hypothetical BLER calculation is more preferred.  Besides, if per-TRP failure report is agreed to be enhanced on Rel-15/16 BFR framework, per-TRP related hypothetical BLER calculation can also be considered. |
| NEC | Support Alt 3-2. |
| Huawei, HiSilicon | We don’t see the motivation here as hypothetical BLER assuming SFN transmission will reduce BFR detection possibilities. |

#### Round-2

**Proposal #4-2:**

* When two TCI states are activated for a CORESET, hypothetical BLER for BFD calculated as follows
  + **Alt 3-2**: UE calculates hypothetical BLER using BFD RS pairs assuming SFN transmission for multiple-TRPs

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| **Company** | **Comment** |
| Moderator | Alt 3-2 has clear majority support |
| Samsung | Support Alt.3-1. It is not clear that how to calculate hypothetical BLER based on BFD RS pairs. |
| Docomo | Support. Since PDCCH reception is SFN, hypothetical BLER should be also calculated by SFN. |
| QC | Support FL proposal. |
| Xiaomi | Support the proposal in principle. And suggest to add the scenario “if the BFD RS is configured implicitly” |
| Ericsson | Support |
| LG | Support the proposal |
| CATT | Do not support Alt 3-2.  As we analyzed in round 1 discussion, Alt 3-2 cannot work well when PDSCH is not configured with SFN transmission. A general failure detection condition which is fit for all scenarios is preferred.  Besides, how to calculate hypothetical BLER based on BFD RS (pairs) can depend on UE implementation, and there is no need to specify it explicitly. |
| vivo | Support |
| MediaTek | Support |
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### Issue #4-3 (NBI RS)

Several companies have discussed the issue of configuration of new beam identification reference signals, when two TCI states are activated for CORESET. Based on the company’s contributions the following alternatives were proposed.

**Issue #4-3:**

* When two TCI states are activated for a CORESET, NBI RS are configured as follows
  + Alt 4-1: Reuse the existing Rel-15 NBI configuration based on single CSI-RS resource
    - **Supported by**: Qualcomm, Nokia/NSB, Intel, OPPO, vivo, MediaTek, Ericsson, Convida Wireless, Sony …
  + Alt 4-2: Introduce two new beam identification CSI-RS resource sets or new beam identification CSI-RS resource pairs
    - **Supported by**: NEC, Xiaomi, Lenovo/MotMobility, CATT

#### Round-1

Companies are invited to provide their views regarding the above alternatives.

**Proposal #4-3:**

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs are required |
| InterDigital | We can discuss this later |
| QC | Support Alt 4-1.  UE should recover with single TRP assumption. |
| OPPO | Support Alt 4-1. |
| vivo | Support Alt 4-1. |
| Nokia/NSB | Support Alt 4-1. |
| MediaTek | Support Alt 4-1 |
| Lenovo/MotM | Support Alt 4-2 to help providing new beam information for later enhanced PDCCH/PDSCH transmission from multiple TRPs for HST |
| Apple | Alt4-1 can be the baseline |
| Ericsson | Support Alt.4-1. UE can always recover with sTRP transmission and could be reconfigured with two TRPs after. |
| Convida Wireless | Support Alt 4-1. |
| Xiaomi | Support Alt 4-2. Since if two TCI states are considered for BFD-RS, but NBI-RS is configured by Alt 4-1, it is much likely that no new beam will be find. |
| Sony | Support Alt 4-1. |
| Docomo | This proposal is related whether to support TRP specific BFD/BFR. In case of cell specific BFR, Alt. 4-1 should be supported. In case of TRP specific BFD/BFR, Alt. 4-2 should be supported. We can firstly discuss whether TRP specific BFD/BFR is supported with SFN PDCCH scheme. |
| CATT | Support Alt4-2. With Alt 4-2, UE can recover with either single TRP transmission or SFN transmission, which depends on the detailed reporting mechanism design. |
| NEC | We share similar view with DoCoMo that it’s better to discuss cell-specific and TRP-specific BFR separately. |

#### Round-2

**Proposal #4-3:**

* When two TCI states are activated for a CORESET, NBI RS are configured as follows
  + For Rel-15/Rel-16 cell-specific BFR, reuse the existing Rel-15 NBI configuration based on single CSI-RS resource
  + FFS for Rel-17 TRP-specific BFR, introduce two new beam identification CSI-RS resource sets or new beam identification CSI-RS resource pairs

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| **Company** | **Comment** |
| Moderator | TRP-specific BFR issues are better to be discussed under 8.1.2.3 |
| Docomo | Support. |
| QC | Support in principles. The 2nd sub-bult is not needed. |
| Xiaomi | If two TCI states are considered for BFD-RS, but NBI-RS is configured by **reusing the existing Rel-15 NBI configuration based on single CSI-RS resource**, it is much likely that no new beam will be find even two new beams can provide better performance by SFN transmission than that of the two old beams. |
| Ericsson | Support. |
| CATT | Support in principle.  About the second bullet, we suggest to draw a conclusion, e.g.,  Conclusion: TRP-specific BFR issues for HST-SFN scenario will be discussed under 8.1.2.3. |
| MediaTek | Support in principle. Agree with Moderator that TRP-specific BFR should be discussed in 8.1.2.3. |
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### Issue #4-4 (Applicability of the BFR enhancements)

Several companies have discussed the issue of applicability of beam failure enhancements for different BFD procedures (specified in different releases), when two TCI states are activated for CORESET. Based on the company’s contributions the following alternatives were proposed.

**Proposal #4-4:**

* When two TCI states are activated for a CORESET, BFR enhancements are applicable to
  + Rel-15 BFR
    - **Supported by**: Qualcomm, NEC, Nokia/NSB, Lenovo/MotMobility,
  + Rel-16 BFR
    - **Supported by**: Qualcomm, NEC, Nokia/NSB, Lenovo/MotMobility,
  + Rel-17 BFR
    - **Supported by**: NEC,

Companies are invited to provide their views regarding the above alternatives.

#### Round-1

**Proposal #4-4:**

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs are required |
| InterDigital | Rel-16 BFR should be the reference. |
| QC | Enhancement should be applicable to BFR Rel.15 and Rel.16 |
| Nokia/NSB | Rel-17 Per-TRP BFR is still under discussion. We can discuss it later. |
| Lenovo/MotM | Enhancement can be applicable to Rel-15 and Rel-16 BFR |
| Apple | Do not fully understand the question, we do not even support two TCI state in CORESET for Rel-15/16. |
| Ericsson | Support enhancement over Rel-15 and Rel-16 |
| Convida Wireless | It depends on what kind of BFR enhancements that are agreed, if any. |
| Xiaomi | Support enhancement for Rel-15/16 cell specific BFR first. Rel-17 TRP specific BFR can be discussed later. |
| Docomo | Support enhancement for Rel-15/16 cell specific BFR first. We are also supportive Rel-17 TRP specific BFR as next step. |
| CATT | We prefer to support per-TRP BFR report, and Rel-17 BFR is preferred. It is also fine to support Rel-15/16 BFR related enhancements if per-TRP failure report feature can be supported. With per-TRP BFR report, if one TRP fails and failure event is reported, gNB can switch SFN operation to single-TRP transmission. |
| NEC | We support both Rel-15/16 cell specific BFR and Rel-17 TRP specific BFR. |
| Moderator | In this agenda item, I suggest we focus enhancements over Rel-15/Rel-16 BFR. |

## Other issues

This section contains other issues the companies want to highlight for discussion regarding support of beam failure detection.

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| **Company** | **Comment** |
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## Issue #5-1 (Other non-categorized proposals)

The proposals supported by one company are provided below for consideration in the next RAN1 meetings.

* *A new definition on QCL association relationship of one antenna port and one antenna port group*
* *Support of small delay CDD with a properly adjusted delay offset between TRPs*
* *QCL assumptions between the TRS/CSI-RS and SSB reference RS for scheme 1*
* *Support configuration of combination of SFN and TDM based PDCCH simultaneously*
* *Introduce new QCL type-E with loose Doppler shift relationship between the target and source RS.*
* *Study zone-based configuration for TCI/QCL information to mitigate potential high signaling overhead.*
* *Support variable-rate TRS transmission for HST deployment scenario.*
* *TCI states configured in non-serving cell(s) with PCI either explicitly configured or implicitly associated*
* *DMRS adaptation for HST SFN scenario*
* *UE assisted DMRS adaptation for DL, in which UE provides an indication of the most convenient DMRS configuration*
* *Define new value of CORESETPoolIndex for CORESET with two TCI states*
* *Study PTRS design in case of SFN transmission scheme*
* *Dynamic DMRS configuration signaling to enable DMRS adaptation*
* *New SRS pattern for UL Doppler estimation purpose*
* *SRS allocation for Doppler measurements multiplexing with any UL or DL channel for the addressed UE*
* *Efficient triggering method for SRS transmission*
* *Study TA issue in HST scenario*
* *Support configuration/activation of one or two TCI States for different search spaces in a CORESET for PDCCH SFN transmission.*

# Other issues

This section contains other issues the companies want to highlight.

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| **Company** | **Comment** |
| InterDigital | Given the fact that in an HST scenario, many UEs will require simultaneous update on their TCI states, from signalling overhead perspective it does not make much sense if the TCI update is done for each UE in an individual manner. Therefore, it would be relevant if a group-based beam indication is used for beam indication of a CORESET.  For example, a CORESET can be configured for a group of UEs which its configuration can be provided via a broadcasting signal (e.g., SIB). Then, a group-based beam indication can determine a beam for a CORESET based on an explicit indication using a DCI or a broadcasting signal, wherein the DCI can be a group-common DCI monitored by a group of UEs.  Proposal: Support DCI-based group indication to indicate a beam for a CORESET. |
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# References

[1] RP-193133, New WID: Further enhancements on MIMO for NR, Samsung 3GPP TSG RAN Meeting #86, Sitges, Spain, December 9-12, 2019.

[2] R1-2104203, Enhancement to support HST-SFN deployment scenario, FUTUREWEI.

[3] R1-2104269, Enhancements on high speed train for multi-TRP in Rel-17, Huawei, HiSilicon.

[4] R1-2104295, Further Discussion on HST-SFN, InterDigital, Inc.

[5] R1-2104346, Further discussion and evaluation on HST-SFN schemes, vivo.

[6] R1-2104414, Discussion on enhancements on HST-SFN deployment, Spreadtrum Communications.

[7] R1-2104487, Discussion on HST-SFN transmission schemes, CATT.

[8] R1-2104588, Discussion on Multi-TRP HST enhancements, ZTE.

[9] R1-2104602, Enhancements on HST-SFN deployment, CMCC.

[10] R1-2104657, Enhancements on HST-SFN deployment, Qualcomm Incorporated.

[11] R1-2104735, Enhancements on HST-SFN deployment, OPPO.

[12] R1-2104892, Enhancements to HST-SFN deployments, Intel Corporation.

[13] R1-2105090, Views on Rel-17 HST enhancement, Apple.

[14] R1-2105154, Enhancement on HST-SFN deployment, Sony.

[15] R1-2105249, Discussion on HST-SFN deployment, NEC.

[16] R1-2105276, Enhancements for HST-SFN deployment, Nokia, Nokia Shanghai Bell.

[17] R1-2105294, Enhancements on HST-SFN, Samsung.

[18] R1-2105543, Enhancements on HST-SFN operation for multi-TRP PDCCH transmission, Xiaomi.

[19] R1-2105586, Enhancement on HST-SFN deployment, Ericsson.

[20] R1-2105591, On Enhancements for HST-SFN deployment, Convida Wireless.

[21] R1-2105686, Discussion on HST-SFN deployment, NTT DOCOMO, INC.

[22] R1-2105761, Enhancements for HST-SFN deployment, Lenovo, Motorola Mobility.

[23] R1-2105782, Enhancements on HST-SFN deployment, LG Electronics.

# Appendix (Summary of the agreements)

The agreements made in RAN1#102e, RAN1#103e and RAN1#104e meetings are provided below.

**RAN1#102-e meeting agreements**

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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 |

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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 * Signalling/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 |

**RAN1#103-e meeting**

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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 TCI states   + FFS other details   Note: DMRS and PDCCH/PDSCH from different TRPs are transmitted in SFN manner  **Agreement**  At most two TCI states are supported for HST scenario in Rel-17   * FFS: Whether to support more than two TCI states for FR2 * FFS configuration/signalling details of the TCI states   Note: DMRS and PDCCH/PDSCH from different TRPs are transmitted in SFN manner  **Agreement**  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 based on further evaluations   * **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: Each TCI state in the above variants may be additionally associated with {Spatial Rx parameter} (i.e., QCL-TypeD) * Note: Companies are encouraged to provide evaluation results for the above variants based on agreed EVM from RAN1#102e meeting * Note: Above variants are applicable to scheme 1 and/or TRP based pre-compensation as a reference for evaluation. * This agreement is for the purpose of evaluation and does not imply the support or lack of support of scheme 1 and/or TRP based pre-compensation |

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| **Agreement**  For PDCCH reliability enhancements, support SFN scheme + Alt 1-1.   * FFS: TCI state activation for CORESET, impact on default beam, BFD resource for BFR   Where the Alt 1-1 is agreed as:  Alt 1-1: One PDCCH candidate (in a given SS set) is associated with both TCI states of the CORESET. |

**RAN1#104-e meeting**

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| **Agreement**  Scheme 1 is supported in Rel-17   * TRS is transmitted in TRP-specific / non-SFN manner * DM-RS and PDCCH/PDSCH from TRPs are transmitted in SFN manner * FFS other details     **Agreement**  For scheme 1 and SFN transmission of PDCCH support Variant E for QCL assumption in TCI state when TRS is used as source RS    **Agreement**  Two TCI states are supported for scheme 1 in FR2  **Agreement**   * Support MAC CE activation of two TCI states for PDCCH * FFS other details   **Conclusion**  The decision on support of specification based TRP pre-compensation scheme for HST-SFN scenario to be made in RAN1#104-e-bis meeting. To facilitate RAN1 decision, companies are encouraged to provide evaluation results according to the agreed evaluation assumptions. The evaluations not compliant with agreed assumptions will not be considered by RAN1 in the decision process.  **Agreement**  For HST-SFN scenario:   * Support semi-static (RRC based) switching of scheme 1 (PDSCH) with 2a, 2b, 3, 4 * FFS all other details including RRC signaling, possible RAN4 impact (if any), etc. |

**RAN1#104b-e meeting**

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| **Agreement**  Introduce enhanced MAC CE signaling for PDCCH activating two TCI states for SFN-based PDCCH transmission   * The corresponding MAC CE includes at least the following fields   + Serving cell ID   + CORESET ID   + Two TCI state IDs * FFS whether for CA scenario additionally support RRC configured set of the serving cells which can be addressed by a single MAC CE * FFS whether or not enhanced MAC CE signaling is applicable to a CORESET configured with CORESETPoolindex   Send LS to RAN2 to inform about agreement on support of enhanced MAC CE for CORESET in Rel-17. LS is endorsed in R1-2104064  **Agreement**  Specification-based TRP Doppler pre-compensation scheme is supported in Rel-17 for FR1 with one or both:   * UL RS based Doppler estimation by gNB   + FFS: Details including UL RS enhancement * DL RS based Doppler feedback by UE   + FFS: Details   + FFS: Whether UE capability needs to be introduced * Whether to support one or both will be decided later   **Agreement**   * Support dynamic (DCI-based) switching of scheme 1 (PDSCH) with single-TRP scheme by TCI state field in DCI format 1\_1/1\_2   + This feature is UE optional * FFS all other details including RRC signalling, possible RAN4 impact (if any), etc.   **Working Assumption**  All QCL source RS resource types as defined in TCI state for Rel-16 multi-TRP are supported for scheme 1  **Agreement**  Support semi-static (RRC-based) switching of scheme 1 (PDSCH) with Rel-16 scheme 1a   * FFS: Whether dynamic switching is additionally supported   **For future meeting:**  Companies to consider Proposal #3-8a in FL summary (R1-2104020) for future meetings.  Companies to consider Proposal #3-10 in FL summary (R1-2104020) for future meetings.  **Agreement**  Scheme 1 for PDSCH is identified by   * New RRC parameter and the number of TCI states indicated by DCI   + FFS RRC configuration details, e.g., per BWP or per CC   + FFS whether or not restriction to a single CDM group for DM-RS is also supported |