**3GPP TSG RAN WG1 #107-e R1-211xxxx**

**e-Meeting, November 11th – 19th, 2021**

**Source: Moderator (Intel Corporation)**

**Title: Draft summary#1 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 companies’ and moderator’s proposals.

# Possible enhancements for HST-SFN deployment

## General issues

### Issue #1-1 (Transmission schemes for PDCCH and PDSCH)

Regarding combinations of the transmission schemes for PDCCH and PDSCH that can be supported with enhanced SFN transmission schemes. Several companies have mentioned that SFN PDSCH may have worse performance comparing to Rel-16 multi-TRP repetition schemes for PDSCH. Considering this, it was proposed to also allow combination of Rel-17 SFN PDCCH and Rel-16 multi-TRP PDSCH schemes for URLLC application. Moreover, one company has mentioned that single TRP PDSCH should be also supported with TRP-based pre-compensation scheme for PDCCH.

#### Round-1

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|  |  | PDSCH | | | |
| PDCCH |  | Rel-15 | Rel-16 | Scheme 1 | Pre-compensation |
| Rel-15 | N/A | N/A | Supported | Supported |
| Rel-17 URLLC | N/A | N/A |  |  |
| Scheme 1 | Supported | Yes: LGE, DOCOMO  No: QC, | Supported | Not supported |
| Pre-compensation | Yes: CMCC | Yes: LGE  No: QC, | Not supported | Supported |

**Proposal #1-1:**

* TBD

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| **Company** | **Comment** |
| Moderator | Please provide your preference directly in the table above focusing on the cases highlighted in yellow. In this table provide justification why the proposed combination should or should not be supported. |
| OPPO | We don’t think any further scheme combination needs to be supported. There is no use case for a PDCCH with pre-compensation to schedule a Rel-15 PDSCH. Also, SFNed PDCCH scheduling Rel-16 PDSCH is also a corner scenario, and will introduce very complex cases for default TCI states. |
| DOCOMO | For URLLC use-case, we think it is useful to consider the case that Scheme1 PDCCH schedules Rel.16 M-TRP PDSCH repetition. |
| ZTE | Support combination of Rel-17 SFN PDCCH scheme1 and Rel-16 multi-TRP PDSCH schemes for URLLC application. This is similar as PDCCH repetition agreed in agenda 8.1.2.1 in which PDCCH repetition can be used for any PDSCH schemes. In our view, Rel-16 MTRP PDSCH is better than SFN PDSCH (already justified by simulation results in Rel-16). However, we have no way to support Rel-16 MTRP for PDCCH. Hence, Rel-17 SFN PDCCH + Rel-16 multi-TRP PDSCH is the best combination. |
| Lenovo/MotM | We agree with OPPO. We already discussed the different scheme combinations, not sure why we need to continue the discussion until all scheme combinations are supported |
| MediaTek | Agree with OPPO. No more combinations are need |
| QC | We don’t think any other combination should be supported. This discussion should be concluded with the already supported combination and no further combination is supported. |
| Ericsson | We think Rel-17 SFN PDCCH Scheme 1 + Rel-16 multi-TRP PDSCH schemes can be supported for URLLC application |
| LGE | Same view with DOCOMO/ZTE/Ericsson. |
| vivo | Don’t support the combination of Rel-17 SFN PDCCH + Rel-16 MTRP PDSCH, which is too complex for UE reception. The combination of Rel-17 SFN PDCCH + Rel-17 SFN PDSCH is a more appropriate way to keep the consistency of the reception algorithms for PDSCH and PDCCH. |
| Sony | We also feel it is not necessary to exhaustively combine all the possible schemes. If what has been greened in the table fails in real-life deployment, then it’s time to re-visit the combinations again. |
| NEC | Same view with DoCoMo/ZTE/Ericsson/LG, support combination of Rel-17 SFN PDCCH + Rel-16 MTRP PDSCH. |
| Spreadtrum | We also don’t think more combination is needed. The use case and benefit is not clear for us. |
| CATT | Agree with OPPO, no more combinations are need. |
| Nokia/NSB | Share view with DCM/ZTE/Ericsson/LG/NEC. |
| Moderator | Scheme 1 PDCCH + Rel16 mTRP PDSCH (7): NTT DOCOMO, ZTE, Ericsson, LGE, NEC, Nokia/NSB, Intel  No more combinations (8): OPPO, Lenovo/MotMob, Mediatek, Qualcomm, vivo, Sony, Spreadtrum, CATT |

### Issue #1-2 (RRC configuration of CC sets for MAC CE activation)

Regarding configuration of the CC list that can be addressed by single MAC CE entry. In RAN1#106b-e meeting, it was agreed as working assumption to reuse the existing Rel-16 RRC parameters defined for PDSCH. In this meeting several companies proposed to confirm the working assumption.

#### Round-1

**Proposal #1-2:**

* Confirm the working assumption from RAN1 #106b-e meeting to reuse legacy Rel-16 RRC parameters *simultaneousTCI-UpdateList1*, *simultaneousTCI-UpdateList2* to define set of the serving cells which can be addressed by a single MAC CE for activation of two TCI states of CORESET with the same CORESET ID for all the BWPs.

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| **Company** | **Comment** |
| Moderator | It seems most of the companies are OK to confirm the working assumption |
| OPPO | Support. |
| DOCOMO | Support |
| ZTE | Support |
| Lenovo/MotM | Support |
| MediaTek | Support |
| QC | Support |
| Ericsson | Support |
| Xiaomi | Support |
| LGE | Support |
| vivo | Support |
| Huawei, HiSilicon | We are fine with the proposal. |
| Sony | Support |
| NEC | Support |
| Sony | Support |
| CATT | Support |
| Nokia/NSB | Support |

### Issue #1-3 (TCI state update for CORESETs on BWPs/CC not configured with SFN)

In RAN1#106-e meeting it was agreed to study whether and how to update the CORESET with TCI state that is not configured to SFN scheme in the indicated CCs set. The following proposals were made to this issue.

**Issue#1-3:**

* For CCs not configured with SFN, 1st TCI state of the two indicated TCI states is selected.
  + **Supported by (4)**: NTT DOCOMO, CATT, Lenovo / MotMobility
* UE doesn’t expect to receive a MAC-CE activating two TCI states of a CORESET that is not identified for SFN scheme by RRC
  + It is up to editor whether and now to capture this in the specification
  + **Supported by (15)**: ZTE, Nokia / NSB, Qualcomm, OPPO, MediaTek, Sony, Ericsson, Xiaomi, LGE, vivo, Huawei / HiSilicon, Sony, Spreadtrum, Nokia/NSB, Intel

#### Round-1

**Proposal#1-3:**

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| **Company** | **Comment** |
| Moderator | More inputs are needed for this issue |
| OPPO | We prefer Alt 2 (UE doesn’t expect to receive a MAC-CE activating two TCI states of a CORESET that is not identified for SFN scheme by RRC). The UE behavior for TCI update for a CC list and TCI activation within a CC should be consistent. |
| DOCOMO | Support Alt.1 (select 1st TCI state of the two indicated TCI states). |
| ZTE | No need for any further discussion. It will be up to implementation as Rel-16 in which the same issue happens for MTRP PDSCH. |
| Lenovo/MotM | We support the first TCI state of the two indicated TCI states is selected as the TCI state for PDCCH transmission in CC that is not configured with SFN. We think it is beneficial that one MAC-CE updates TCI states for PDCCH transmission in the CC in multi-TRP mode as well as PDCCH transmission in another CC in single-TRP mode simultaneously, which saves some RRC signaling overhead |
| MediaTek | Support “UE doesn’t expect to receive a MAC-CE activating two TCI states of a CORESET that is not identified for SFN scheme by RRC” |
| QC | We support Alt 2 (UE doesn’t expect to receive MAC-CE activation two TCI states of a CORESET that is not identified by SFN PDDCH scheme RCC) |
| Ericsson | We are fine with Alt2. |
| Xiaomi | We prefer Alt 2 which is clearer for UE. |
| LGE | Support Alt2. It is not clear why CCs configured with SFN and CCs not configured with SFN are in the same CC list. |
| vivo | Fine with Alt2. |
| Huawei, HiSilicon | We are fine with Alt 2. |
| Sony | First, we think the CC in SFN mode and the CC not in SFN mode should not be configured in the same CC list.  But if NW chooses to do so, we are then fine with Alt.2 |
| Spreadtrum | Prefer Alt 2. It is very clean and simple. |
| CATT | For Alt 1, both SFN-ed and non-SFN-ed CORESETs can be configured flexibly in an indicated CC set and activated with one or two TCI states simultaneously by one single MAC-CE. Hence, we support Alt 1. |
| Nokia/NSB | Prefer Alt 2. |
| Moderator | **Proposal#1-3:**   * UE doesn’t expect to receive a MAC-CE activating two TCI states of a CORESET that is not identified for SFN scheme by RRC   + It is up to editor whether and now to capture this in the specification |

### Issue #1-4 (Restriction of SFN scheme configuration)

In RAN1#105-e meeting, it was agreed that mixed SFN modes (scheme-1 and TPR-based pre-compensation) is not expected across CORESETs and across PDSCH. However, it is still FFS whether different SFN schemes are possible in different CCs or not according to the agreement below.

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| **Agreement**   * 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 * UE does not expect to be configured different SFN schemes (scheme 1 or TRP pre-compensation) for both PDCCH and PDSCH.   + FFS whether this restriction is per UE or per CC * UE does not expect to be configured different SFN schemes (scheme 1 or TRP pre-compensation) for different CORESETs.   + FFS whether this restriction is per UE or per CC |

**Issue#1-4:**

The configuration restriction of different SFN schemes for PDCCH and PDSCH is defined

* **Alt 1.** Per-CC group
  + **Supported by**: Qualcomm,
* **Alt 2**: Per CC
  + **Supported by**: DOCOMO

#### Round-1

**Proposal#1-4:**

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs from other companies are required |
| OPPO | Support per UE configuration. |
| DOCOMO | Prefer per CC configuration. |
| ZTE | We don’t need to discuss all such cases which can be handled in IODT stage. |
| Lenovo/MotM | We prefer per CC group configuration |
| MediaTek | Prefer Per-CC group |
| QC | Per-CC means that UE needs to be prepared to support different schemes (sfn scheme A and sfn scheme B) on two different CCs and/or different bands which increase UE complexity. We prefer per CC-group, and we are fine with per-UE as well. |
| Ericsson | We prefer per-CC configuration. |
| Xiaomi | Prefer Per-CC group or per UE. |
| LGE | Prefer per-CC group configuration |
| vivo | In our understanding, “UE does not expect to be configured different SFN schemes (scheme 1 or TRP pre-compensation) for both PDCCH and PDSCH” just means that PDCCH and PDSCH should be configured as the same SFN schemes simultaneously (scheme 1 or TRP pre-compensation), if they are both working in SFN mode. From this perspective, this configuration restriction has nothing to do with per UE or per CC.  Therefore, I guess we are actually discussing another restriction. That is whether different SFN schemes can be configured in different CCs, right? If yes, we support per CC-group.  In order to disambiguate the meaning of the mentioned restriction, we suggest the following revision:  The same configuration of SFN schemes is expected   * **Alt 1.** Per-CC group * **Alt 2**: Per CC   Additionally, per CC has been agreed in the previous meeting.  **Agreement**  Enhanced SFN (scheme 1 or TRP-based pre-compensation scheme) for PDCCH and PDSCH is configured by using separate per-BWP RRC parameters   * In Rel-17, all downlink BWPs (except initial BWP and FFS: BWP-DownlinkCommon) within a CC should be the same configuration of SFN scheme |
| Huawei, HiSilicon | Per-CC is preferred. |
| Sony | We are fine with Per-CC group or Per UE (if per UE can be added as Alt 3 from FL). |
| Spreadtrum | Prefer per UE or per-CC group |
| CATT | We prefer per CC configuration. |
| Nokia/NSB | Prefer Per-CC. |
| Moderator | Summary of the companies’ views are provided below, where slight majority prefers to have the same scheme across CCs within CC group:  **Proposal#1-4:**  UE doesn’t expect configurations of different SFN schemes in different CCs within CC group   * **Supported (8):** OPPO (per UE), Mediatek, Lenovo/MotMob, Qualcomm, Xiaomi, LGE, Sony, Spreadtrum, * **Not supported (6):** Ericsson**,** DOCOMO, ZTE (no need to discuss), Huawei / HiSilicon, CATT, Nokia / NSB |

### Issue #1-5 (RRC configuration of SFN scheme for BWPs)

One if the open issues related to support of SFN scheme for PDCCH is whether SFN scheme can be configured for BWP-DownlinkCommon according to the FFS from RAN1#106b-e meeting:

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| **Agreement**  Enhanced SFN (scheme 1 or TRP-based pre-compensation scheme) for PDCCH and PDSCH is configured by using separate per-BWP RRC parameters   * In Rel-17, all downlink BWPs (except initial BWP and FFS: BWP-DownlinkCommon) within a CC should be the same configuration of SFN scheme |

One company in [14] has made proposal to remove the FFS from the previous agreement.

#### Round-1

**Proposal #1-5**:

Update RAN1#106b-e meeting agreement by removing the “FFS:”

* Enhanced SFN (scheme 1 or TRP-based pre-compensation scheme) for PDCCH and PDSCH is configured by using separate per-BWP RRC parameters
  + In Rel-17, all downlink BWPs (except initial BWP and ~~FFS:~~ BWP-DownlinkCommon) within a CC should be the same configuration of SFN scheme

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| **Company** | **Comment** |
| Moderator | More inputs are required from other companies |
| OPPO | We don’t think *BWP-DownlinkCommon* should be here. *BWP-DownlinkCommon* is not an actual BWP according to 38.331. There will not be parameter for SFN configuration in *BWP-DownlinkCommon*. – *BWP-DownlinkCommon* The IE *BWP-DownlinkCommon* is used to configure the common parameters of a downlink BWP. They are "cell specific" and the network ensures the necessary alignment with corresponding parameters of other UEs. The common parameters of the initial bandwidth part of the PCell are also provided via system information. For all other serving cells, the network provides the common parameters via dedicated signalling. |
| DOCOMO | Agree with OPPO. |
| ZTE | I think everyone is in the same page that *BWP-DownlinkCommon* is not an actual BWP. We support FL proposal to make things clearer. The detailed design will be up to RAN2. |
| Lenovo/MotM | More discussion is preferred for removing “FFS” since this BWP is configured after RRC connection |
| QC | The whole FFS with the word BWP-DownlinkCommon should be removed.  ~~FFS: BWP-DownlinkCommon~~ |
| Ericsson | Support |
| vivo | Support to remove “FFS: BWP-DownlinkCommon”. |
| Sony | Agree with the observation from OPPO, ZTE and QC. The whole FFS needs to be removed, unless it can be verified that the FFS points to another BWP, e.g. default BWP, which cannot be configured with SFN scheme. |
| NEC | Agree with OPPO. |
| Spreadtrum | Fine to remove the whole FFS part |
| CATT | Agree with OPPO and ZTE. |
| Nokia/NSB | Agree with OPPO. |
| Moderator | There are several concerns to remove FFS. |

### Issue #1-6 (Remaining details of RRC configuration and MAC CE usage)

One company in [22] has proposed to consider the case when only two TCI states are RRC-configured for SFN CORESETs. The following proposal is made to support this scenario.

#### Round-1

**Issue #1-6**:

* For a CORESET that is indicated with SFN mode by higher layer signalling and RRC-configured with only two TCI states, the UE assumes that the DM-RS antenna port associated with PDCCH receptions in the CORESET are QCL-ed with the DL RSs in the two TCI states.

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| **Company** | **Comment** |
| Moderator | The issue has been discussed in the previous meeting. Since it is related to signaling design, one option is to leave this decision up to RAN2 decision. |
| OPPO | Fine to leave it to RAN2. |
| DOCOMO | Support the proposal. We agree with the following observation in [22].  **Observation 12: Rel-17 MAC-CE activation of two TCI states for SFN PDCCH is required only when more than two TCI states are RRC configured in the CORESET.** |
| ZTE | Don’t support. MACCE can either activate one or two TCI states for STRP and SFN respectively even only two TCI states are configured by RRC. It is noted that SFN mode is indicated per BWP rather than per CORESET. |
| Lenovo/MotM | We do not see the necessity for more specification on this since “RRC-configured with only two TCI states” is not a common configuration and since MAC CE activation scheme is already agreed. |
| MediaTek | Seems unnecessary |
| QC | It is important to understand UE behavior when SFN PDCCH schemes is configured by RRC and a CORESET is configured with only two TCI states, but didn’t receive either Rel-15 MAC-CE or Rel-17 MAC-CE. |
| Ericsson | Support. |
| Xiaomi | Share same view as ZTE. MAC CE is needed to active one or two TCI state. |
| LGE | Same view with ZTE. Furthermore, the following agreement shows that MAC CE activation of two TCI states is required to identify enhanced SFN PDCCH scheme.  **Agreement**  Enhanced SFN PDCCH transmission scheme (scheme 1 or TRP-based pre-compensation) is identified **by the number of TCI states activated per CORESET** and RRC parameter   * FFS: Configuration detail of RRC parameter   Including whether the same RRC parameter is used for PDCCH and PDSCH |
| vivo | We don’t support the proposal. If SFN PDCCH is configured and only one TCI state is activated by MAC CE, UE would work in STRP mode. Therefore, that only two TCI states are configured by RRC can’t determine the SFN mode for PDCCH. In other words, if SFN PDCCH is configured, MAC CE is expected to indicate the TCI state(s) for CORESET. |
| Huawei, HiSilicon | Share similar view as ZTE. |
| Sony | It seems not necessary to enhance this special case in Spec.  In Rel.16, there is configured TCI state pool in *PDSCH-Config* per BWP and no such dedicated pool for PDCCH. And the activated TCI state for a CORESET is picked up by MAC CE from this pool. If only 2 TCI states are configured in *PDSCH-Config*, it seems not a very common case. |
| Spreadtrum | Support the proposal, also fine to leave it to RAN2. |
| CATT | Not support. The following agreement has been achieved in #105-e meeting,  **Agreement**  *Enhanced SFN PDCCH transmission scheme (scheme 1 or TRP-based pre-compensation) is identified by the number of TCI states activated per CORESET and RRC param*eter  In our opinion, SFN-ed CORESET is indetified by both MAC-CE and RRC. So similar view as ZTE, MAC-CE can either activate one or two TCI states for STRP and SFN respectively even if only SFN-ed transmission scheme is configured by RRC. |
| Nokia/NSB | Up to RAN2 |
| Moderator | There are concerns to adopt this proposal. |

### Other issues

This section contains other issues that companies want to highlight for discussion regarding general issue.

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| **Company** | **Comment** |
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## UE-based solutions

### Issue #2-1 (Dynamic switching of scheme 1 and scheme-1a)

Regarding support of 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#2-1:** Additional support of dynamic switching of scheme 1 and Rel-16 scheme-1a

* **Supported**: Huawei / HiSilicon, CATT, …
* **Not supported:** Qualcomm, OPPO, NEC, Nokia/NSB, Lenovo/MotMobility, Apple, Mediatek …

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

#### Round-1

**Proposal #2-1 (for conclusion):**

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

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| **Company** | **Comment** |
| Moderator | This is low priority issue, since the situation is the same as in the previous meeting. |
| OPPO | Support. |
| DOCOMO | We are fine with either. |
| ZTE | Don’t need this clear conclusion. |
| Lenovo/MotM | Support moderator’s proposal |
| MediaTek | Support the conclusion |
| QC | Support the conclusion. |
| Ericsson | Fine with the conclusion. |
| vivo | Support the conclusion |
| 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/ TRP-based pre-compensation here.  For HST, the rapid changes of environment would result in channel property changes and rank adaptation, which means that proper transmission scheme should be used. For low rank environment, SFN transmission would be more suitable. While for high rank, it’s difficult to align the phases between both TRPs for all layers in SFN, while NCJT is more efficient in such scenarios. Therefore, to adapt to changing channels, it's beneficial in terms of spectral efficiency and reliability to switch NCJT and SFN dynamically. |
| Sony | Support the conclusion. |
| NEC | Support the conclusion. |
| Spreadtrum | Support |
| CATT | We can accept this conclusion at this stage of Rel-17. |
| Nokia/NSB | Support the conclusion. |

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

Regarding support of scheme 2. A few companies expressed their preference regarding support of scheme 2 in Rel-17. Summary of the companies’ views are provided below.

**Issue#2-2:** 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, ZTE, …

#### Round-1

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

* Scheme 2 is not supported in Rel-17

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| **Company** | **Comment** |
| Moderator | This is low priority issue, since the situation is the same as in the previous meeting. |
| OPPO | Support. No further discussion is needed. |
| DOCOMO | Support. |
| ZTE | No further discussion is needed. |
| Lenovo/MotM | Support moderator’s proposal |
| MediaTek | Support the conclusion |
| QC | Support. |
| Ericsson | Fine with the conclusion |
| vivo | Support |
| Huawei, HiSilicon | Support the proposal. |
| Sony | Support. |
| Spreadtrum | Support |
| CATT | Support. |
| Nokia/NSB | Support the conclusion. |

### Other issues

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

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## TRP-based solutions

### Issue #3-1 (TRP-based pre-compensation in FR2)

Regarding support of TRP-based pre-compensation scheme for FR2. Several companies proposed to extend support of TRP-based pre-compensation to FR2, while one company mentioned lack of technical justification of such enhancement. Summary of the companies’ preference is provided below.

**Issue#3-1:**

* TRP-based pre-compensation scheme for PDSCH / PDCCH is only supported in FR1
  + **Supported**: Futurewei, Ericsson
* TRP-based pre-compensation scheme for PDSCH / PDCCH is supported in both FR1 and FR2
  + **Supported**: CMCC, DOCOMO, ZTE, Lenovo / MotMobility, Huawei/HiSilicon, CMCC, NTT DOCOMO, Qualcomm, Sony

Based on majority view the following proposal is made.

#### Round-1

**Proposal #3-1:**

* TRP-based pre-compensation scheme for PDSCH / PDCCH is supported in both FR1 and FR2 with UE capability per FR

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| **Company** | **Comment** |
| Moderator | In case we don’t have sufficient time to conclude on this, RAN1 can take this issue for further discussion in UE capability sessions. |
| OPPO | Fine to it. |
| DOCOMO | Support. |
| ZTE | Support this feature in FR2 as there is no extra spec effort needed. Support FL proposal. |
| Lenovo/MotM | Agree with moderator’s assessment. We are also OK to make FR2 capability support conditional on FR1 capability |
| MediaTek | Support |
| QC | Support. |
| Ericsson | Do not support.  As we explained in our contribution:  In FR2, the beams are narrow. Multiple antenna panels are typically used at the UE in order to receive signals simultaneously from two TRPs such as in the case of SFN transmission, where each panel is dedicated to receive signals from one TRP as illustrated in Figure 1. In this case and under line of sight (LOS) condition, which is the typical case in HST-SFN, each antenna panel receives mainly signals from one of the TRPs. Channel estimation is performed in a per panel basis and signals from different panels may be further combined with MRC or MMSE after channel estimation as illustrated in Figure 1. Since each panel receives mainly signals from one TRP, only one dominate Doppler frequency (either positive or negative) would be included in the received signal at each panel. With such panel setting assumption, the large Doppler spread issue in FR1 may not exist in FR2.  Ch. est.  Ch. est.  MRC  TRP1  TRP1  UE  Antenna  panels  Figure 1: An example of UE implementation of SFN in FR2.  We have been asking proponent company in many meetings: What are the settings and assumptions that the pre-compensation can be beneficial for FR2? If there are companies consider pre-compensation is essential for FR2 and can prove it, we are open for discussion. |
| LGE | Support |
| vivo | We are not sure whether all UE can support the channel estimation performed in a per panel. For the UEs don’t have the capability, TRP-based pre-compensation scheme is beneficial in FR2. |
| Huawei, HiSilicon | Support the proposal.  For Ericsson’s comments, in implementation, the UE can combine the signals from multiple panels directly, and do channel estimation and decoding just one time, to reduce UE complexity. The example given by Ericsson would significantly increase UE complexity by twice. On the benefits, when Doppler shift occurs, we don’t see any essential difference on benefits between FR1 and FR2. More elaboration from Ericsson would be appreciated. |
| Sony | Support.  Thanks to Ericsson for illustrating the TRP-specific Doppler pre-compensation. Our thinking is that if we are talking about the UE mounted on top of a train or vehicle and equipped with two back-to-back antenna panels, then the inter-panel interference can be neglected. But if we are referring to handhold UE within a carriage, it seems the rich scattering environment would bring inter-panel interference and therefore the Doppler pre-compensation could be beneficial. |
| NEC | Fine with the proposal. |
| Spreadtrum | Support |
| CATT | Support. |
| Moderator | It seems there is valid example, that some UE may perform SFN like combining of the signals received in different panels in FR2. I’d like to ask E/// to accept the proposal #3-1 for the progress.  **Proposal #3-1:**   * TRP-based pre-compensation scheme for PDSCH / PDCCH is supported in both FR1 and FR2 with UE capability per FR |

### Issue #3-2 (Support of Variant B for TRP-based pre-compensation)

In RAN1#106e meeting working assumption on QCL assumptions to assist TRP-based pre-compensation scheme was confirmed. However, it is FFS whether Variant B should be additionally supported as QCL assumptions. Companies’ views on this issue are summarized below.

**Issue#3-2:** Whether to support Variant B for TRP-based pre-compensation as QCL types/assumption, when the same DMRS port(s) are associated with two TCI states

* Variant B is supported
  + **Supported**: Qualcomm, Intel, …
* Variant B is not supported
  + **Supported**: Mediatek, CATT, Huawei / HiSilicon, Futurewei, CATT, Mediatek, Nokia / NSB, Lenovo / MotMob, DOCOMO, Sony

Based on the companies’ preference the following proposal is made.

#### Round-1

**Proposal #3-2 (for conclusion):**

* Variant B is not supported for TRP-based pre-compensation as QCL types/assumption, when the same DMRS port(s) are associated with two TCI states

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Moderator | This is low priority issue, since the situation is the same as in the previous meeting. |
| OPPO | Support. No further discussion is needed. |
| DOCOMO | Support. |
| Lenovo/MotM | Support |
| MediaTek | Support |
| LGE | Support |
| vivo | Support |
| Huawei, HiSilicon | Support |
| NEC | Support |
| Spreadtrum | Support |
| CATT | Support. |
| Nokia/NSB | Support the proposal. |
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### Issue #3-3 (SRS enhancements for TRP-based pre-compensation)

In RAN1#106-e meeting it was agreed to support SRS-based Doppler measurements to assist TRP-based pre-compensation scheme. It was also agreed to further study whether enhancements to SRS are required to improve accuracy of the corresponding Doppler shift measurements. Companies’ views on this issue are summarized below.

**Issue#3-3:** For TRP-based pre-compensation

* **Alt-1**: Support SRS enhancements for Doppler shift estimation
  + Support two SRS resources, where each SRS resource is configured with a different spatial relation or PL-RS
  + Introduce new SRS pattern for UL Doppler estimation purpose, comprised of at least two intra slot non-consecutive SRS symbol repetitions with a configurable time gap between the SRS symbols.
  + Introduce new usage type for SRS resource set that will be associated with Doppler tracking purpose. The new SRS pattern will be supported under the new SRS resource set usage type.
  + Implicit Doppler shift indication for HST SFN scenario will be based on SRS resource(s) defined under SRS resource set with the new usage type (Doppler tracking).
  + **Supported**: Qualcomm, Nokia / NSB, InterDigital, Sony…
* **Alt-2**: Not support of SRS enhancements in Rel-17
  + **Supported**: ZTE, Mediatek, Huawei / HiSilicon, ZTE, Mediatek, DOCOMO

#### Round-1

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

* SRS enhancements to support TRP-based pre-compensation scheme are not supported in Rel-17

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Moderator | This is low priority issue, since the situation is the same as in the previous meeting. |
| OPPO | Support the proposal . We can discuss this issue in Rel-18. |
| DOCOMO | Support the Proposal. |
| ZTE | Support the proposal |
| Lenovo/MotM | Support |
| MediaTek | Support |
| QC | Unfortunately, it seems companies more interested to discuss this enhancement in Rel-18 and waste the chance to make it happen in Rel-17. |
| LGE | Support |
| vivo | Support |
| Huawei, HiSilicon | Support |
| Sony | There seems no enough time to complete this enhancement within Rel.17. Possibly to give it a try in Rel.18 MIMO. |
| NEC | Support |
| Spreadtrum | Support |
| CATT | Support. |
| Nokia/NSB | We have still question how to configure SRS resources to two TRPs for this purpose. Existing SRS configuration doesn’t support this operation. At least, this should be resolved for supporting this feature. |
| Moderator | Reagrding Nokia’s concern on spatial relation. According to my understanding per resource spatial relation configuration for SRS is already possible in Rel-15 with maximum of two SRS resources for CB operation.  Companies with concern on the Alt 1, please address Nokia’s question on PL configuration. |

### 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** |
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## Issues related to SFN transmission of PDCCH

### Issue #4-1 (CORESET overlapping with PDSCH)

One company in [16] has mentioned that the existing specification supports prioritization of PDCCH reception, in case qcl-Type set to 'typeD' of PDSCH DM-RS is different from that of the PDCCH DM-RS with which it overlaps in at least one symbol. In Rel-17 further clarification of the specification may be required in case SFN and non-SFN CORESET is overlapped with non-SFN and SFN PDSCH respectively.

**Issue #4-1:**

* Support prioritization of the reception in case CORESET activated one or two TCI states is overlapping with scheduled Rel-17 SFN PDSCH reception in same carrier or intra-band CA
  + FFS other details
* Support prioritization of the reception in case CORESET is overlapping with the scheduled single-TRP PDSCH reception in same carrier or intra-band CA
  + FFS other details
* **Supported by**: Samsung, DOCOMO

#### Round-1

**Proposal #4-1:**

* TBD

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Moderator | This issue has been discussed in the previous RAN1 meeting. Suggest proponent to clarify comments received in the last RAN1 meeting, e..g, why the existing specification is not sufficient to address the considered scenario. |
| OPPO | Low priority. We can discuss it later when the first Rel-17 CR is agreed. |
| DOCOMO | Support the proposal. |
| ZTE | Agree with OPPO |
| Lenovo/MotM | More clarification is preferred as Moderator suggestion |
| MediaTek | Support in principle. Fine with discussing it later |
| Ericsson | We can discuss this later after resolving the PDCCH overlapping issue. |
| Xiaomi | We are open to discuss it. |
| vivo | We can discuss it later. |
| CATT | This issue can be discussed later. |
|  |  |
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### Issue #4-2 (Default TCI for SFN PDSCH without TCI state and offset larger than threshold)

Several companies discussed the issue of PDSCH reception when TCI field is not present in DCI scheduling PDSCH with offset larger than threshold. In particular, whether to additionally support DCI formats 1\_1 and 1\_2 for PDSCH reception scheduled without TCI field. Two alternatives for default TCI state were identified as possible solutions.

**Issue #4-2:**

For unicast PDSCH reception scheduled by DCI format 1\_0, 1\_1, and 1\_2 and if applicable the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL*

* Support configuration when there is no TCI field in the DCI scheduling PDSCH, when SFN is configured for both PDCCH and PDSCH by RRC
  + UE applies the TCI state(s) of the scheduling CORESET when receiving the PDSCH
    - if there are two active TCI states for the CORESET, UE applies the both QCL assumptions of the CORESET that schedules the PDSCH when receiving the PDSCH
    - otherwise, if there is one active TCI states for the CORESET,
      * **Alt 1**:
        + UE applies the one active TCI state of the CORESET when receiving the PDSCH
        + if the UE does not support this feature UE is expected to be configured with TCI field
      * **Alt 2**:
        + If UE supports dynamic switching between single-TRP and SFN PDSCH

UE applies the one active TCI state of the CORESET when receiving the PDSCH

* + - * + Else

UE obtains it’s QCL assumption for the scheduled PDSCH from the lowest codepoint containing two different TCI states

**Supported**: Huawei / HiSilicon (Alt 1), DOCOMO (Alt 1), Nokia / NSB (Alt 1), Ericsson (Alt 2), Samsung, Lenovo / MotMob (Alt 1?)

#### Round 1

**Proposal #4-2:**

* TBD

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Moderator | More inputs are required from other companies |
| OPPO | Support Alt 1. |
| DOCOMO | Support Alt.1. For Alt.2, there is no relation between the “dynamic switching capability” and the proposed behavior, because the “dynamic switching capability” is by TCI state field. |
| ZTE | Support Alt 1 |
| Lenovo/MotM | Support Alt 1 |
| MediaTek | Support Alt 1 |
| QC | DON’T SUPPORT.  We still don’t see the benefits for TCI field not present in the DCI as it complicates the discussion and makes UE implementation more complex. As discussed, several times in the last meeting, to make progress on that feature, we should discuss the following for Alt 1   * The relationship between support of this feature and dynamic switching. If UE supports this feature and not capable of dynamic switching, then scheduling CORESET for DCI format 1\_1, 1\_2 and 1\_0 should be activated with two TCI states. * For DCI format 1\_0, if UE doesn’t support this feature and not capable of dynamic switching, then we should clarify UE behavior for DCI format 1\_0 as well. DCI format 1\_0 can be used for unicast data (e.g., C-RNTI, CS-RNTI) scheduling and non-unicast PDSCH (e.g., SI-RNTI, P-RNTI, etc.). Then, we should make sure that scheduling CORESET of unicast DCI format 1\_0 should be activated with two TCI states. |
| Ericsson | Support Alt 2. We think Alt2 is the solution to work around the restriction of dynamic switch. We are also fine to support Alt 1 if UE can still support 1\_0. UE shall always support DCI 1\_0 regardless of UE capability.  Suggest to update the main bullet:  For unicast PDSCH reception scheduled by DCI format 1\_0, 1\_1, and 1\_2 and if applicable the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL* |
| Xiaomi | Prefer Alt 1 |
| LGE | Support Alt1 |
| vivo | Support Alt 1 |
| Huawei, HiSilicon | Support Alt 1. |
| Spreadtrum | Prefer Alt1 |
| CATT | Support Alt 1. |
| Nokia/NSB | Support Alt1. |
| Moderator | It is better to minimize dependencies among different UE capabilities. Just wan to check whether the following proposal would be acceptable  **Proposal #4-2:**  For unicast PDSCH reception scheduled by DCI format 1\_0, 1\_1, and 1\_2 and if applicable the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL*   * Support configuration when there is no TCI field in the DCI scheduling PDSCH, when SFN is configured for both PDCCH and PDSCH by RRC * UE applies the TCI state(s) of the scheduling CORESET when receiving the PDSCH   + if there are two active TCI states for the CORESET, UE applies the both QCL assumptions of the CORESET that schedules the PDSCH when receiving the PDSCH   + otherwise, if there is one active TCI states for the CORESET, UE applies the one active TCI state of the CORESET when receiving the PDSCH * if the UE does not support configuration without TCI field   + For DCI formats 1\_1 and 1\_2, UE excepts configuration with TCI field   + For DCI format 1\_0, the scheduling CORESET for unicast PDSCH should be activated with two TCI states |
|  |  |

### Issue #4-3 (Additional default TCI for non-SFN PDSCH and scheduling without TCI and offset larger than threshold)

One company in [5] has mentioned that when SFN PDSCH is not configured by RRC, UE is expected to operate in single TRP scheme. However, when the CORESET which schedules the PDSCH is indicated with two TCI states, if UE applies both TCI states of CORESET as the default TCI states, UE will operate using SFN scheme. It is proposed to define default TCI state assumption as the first TCI state of the CORESET for this case to keep the single TRP transmission.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Case** | **SFN PDSCH configured by RRC** | **TCI state(s) of the CORESET** | **Dynamic switching** | **Default TCI state** |
| 4 | No | Two | Support | The first TCI state of the CORESET that schedules the PDSCH |
| Not support |

**Issue #4-3:**

* If the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL*, there is no TCI field in the DCI, SFN PDSCH is not configured by RRC, the CORESET which schedules the PDSCH is indicated with two TCI states, the default TCI state is defined as the first TCI state of the CORESET.

#### Round 1

**Proposal #4-3:**

* TBD

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Moderator | More inputs are required from other companies |
| OPPO | Support. |
| DOCOMO | Support. We suggest to add “if applicable” after “*timeDurationForQCL*”, because the proposal is also applicable to FR1. |
| ZTE | Support |
| Lenovo/MotM | We think this issue is related to Issue #1-1 whether Rel-16 M-TRP PDSCH could be scheduled by SFN PDCCH. We prefer to discuss it later |
| MediaTek | Support |
| QC | Don’t support  No motivation to make TCI filed not present in that corner case |
| Xiaomi | Support since the combination of Rel-17 SFN PDCCH scheme 1 and single-TRP PDSCH was supported. |
| LGE | Support  Scheme combination of Rel-17 scheme 1 PDCCH + Rel-15 PDSCH was agreed. So, the proposal should be supported considering at least DCI format 1\_0. |
| vivo | Support. If SFN PDSCH is not configured by RRC, but two TCI state is used according to the default TCI state rules, that would lead to a self-contradictory results. |
| CATT | Support. |
| Nokia/NSB | Support. |
| Moderator | Please find revised proposal.  **Proposal #4-3:**   * If the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL* if applicable, there is no TCI field in the DCI, SFN PDSCH is not configured by RRC, the CORESET which schedules the PDSCH is indicated with two TCI states, the default TCI state is defined as the first TCI state of the CORESET. |

### Issue #4-4 (Default TCI for non-SFN PDSCH and offset smaller than threshold)

In RAN1#106b-e meeting the agreement was made, where condition on “*enableTwoDefaultTCIStates*” was captured in the brackets.

|  |
| --- |
| **Agreement**  When SFN PDSCH is not configured by RRC, for PDSCH reception scheduled by DCI format 1\_0, 1\_1, 1\_2, if the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL,*   * For DCI format 1\_1/1\_2, support both configurations with and without TCI state field. * [If *enableTwoDefaultTCIStates* is not configured,] for both cases with and without TCI state field,   + If enhanced SFN PDCCH transmission scheme 1 is configured and the lowest CORESET ID in the latest slot is indicated with two TCI states, select the 1st TCI state of the two TCI states of the CORESET as default beam for the PDSCH reception     - FFS: Whether above applies for TRP-based pre-compensation if TRP-based pre-compensation is agreed to be support in FR2   + Otherwise, UE applies the one active TCI state of the CORESET with the lowest *controlResourceSetId* in the latest slot when receiving the PDSCH |

Several companies have mentioned that UE may be configured with Rel-16 multi-TRP based PDSCH repetition, where condition on “*enableTwoDefaultTCIStates*” may be needed.

#### Round-1

**Proposal #4-4:**

Revise RAN1#106b-e meeting agreement by removing brackets for the condition “If *enableTwoDefaultTCIStates* is not configured” and extending to TRP-based pre-compensation for PDSCH if supported in FR2:

* When SFN PDSCH is not configured by RRC, for PDSCH reception scheduled by DCI format 1\_0, 1\_1, 1\_2, if the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL,*
  + For DCI format 1\_1/1\_2, support both configurations with and without TCI state field.
  + ~~[~~If *enableTwoDefaultTCIStates* is not configured,~~]~~ for both cases with and without TCI state field,
    - If enhanced SFN PDCCH transmission scheme 1 or TRP based pre-compensation (if supported in FR2) is configured and the lowest CORESET ID in the latest slot is indicated with two TCI states, select the 1st TCI state of the two TCI states of the CORESET as default beam for the PDSCH reception
      * ~~FFS: Whether above applies for TRP-based pre-compensation if TRP-based pre-compensation is agreed to be support in FR2~~
    - Otherwise, UE applies the one active TCI state of the CORESET with the lowest *controlResourceSetId* in the latest slot when receiving the PDSCH

**Supported by:** ZTE, DOCOMO, Nokia / NSB, vivo (remove text in the brackets?), LGE, Xiaomi, Lenovo / MotMob, Lenovo / MotMobility, …

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Moderator | This issue seems dependent whether combination of SFN with Rel-16 multi-TRP PDSCH is allowed or not in Issue #1-1. |
| OPPO | Wait for the conclusion in issue #1-1 |
| DOCOMO | Support the proposal. To remove [ ] of “If *enableTwoDefaultTCIStates* is not configured”, we don’t need to wait conclusion issue #1-1. |
| ZTE | Support FL proposal |
| Lenovo/MotM | Support FL’s proposal |
| MediaTek | Support |
| QC | Two comments:   * We don’t have agreement on support of TRP pre-compensation for PDCCH + non-SFN PDSCH. So, FFF sublet should hold. * Combination of scheme-1 + Rel-16 MTRP PDSCH is not supported. |
| Xiaomi | Support |
| LGE | Support |
| vivo | When SFN PDSCH is not configured by RRC, no matter *enableTwoDefaultTCIStates* is configured or not, UE would work in STRP mode. From this perspective, “If *enableTwoDefaultTCIStates* is not configured” is unnecessary. However, without “If *enableTwoDefaultTCIStates* is not configured”, there would be another problem, that is if SFN PDSCH is not configured by RRC, *enableTwoDefaultTCIStates* is configured and at least one TCI codepoint indicates two TCI states, what is the default beam assumption? According to the Rel-16 rule, two TCI state of the lowest codepoint in MAC CE would be used, which is not expected for the issue we are discussing.  Therefore, one easy way is to restrict that UE is not expected to be indicated by MAC CE with two TCI states per any of TCI codepoint, if SFN PDSCH is not configured by RRC.  **Proposal #4-4:**   * When SFN PDSCH is not configured by RRC, for PDSCH reception scheduled by DCI format 1\_0, 1\_1, 1\_2, if the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL,*   + For DCI format 1\_1/1\_2, support both configurations with and without TCI state field.   + ~~[If~~ *~~enableTwoDefaultTCIStates~~* ~~is not configured,]~~ for both cases with and without TCI state field,     - If enhanced SFN PDCCH transmission scheme 1 or TRP based pre-compensation (if supported in FR2) is configured and the lowest CORESET ID in the latest slot is indicated with two TCI states, select the 1st TCI state of the two TCI states of the CORESET as default beam for the PDSCH reception       * ~~FFS: Whether above applies for TRP-based pre-compensation if TRP-based pre-compensation is agreed to be support in FR2~~     - Otherwise, UE applies the one active TCI state of the CORESET with the lowest *controlResourceSetId* in the latest slot when receiving the PDSCH * UE is not expected to be indicated by MAC CE with two TCI states per any of TCI codepoint for PDSCH, if SFN PDSCH is not configured by RRC. |
| CATT | Support FL proposal. |
| Nokia/NSB | Support |
| Moderator | @vivo. Reagrding the proposal in the last bullet “UE is not expected to be indicated by MAC CE with two TCI states per any of TCI codepoint for PDSCH, if SFN PDSCH is not configured by RRC.” the wording literally means that Rel-16 mTRP is not allowed. Perhaps some additional condition is missing.  **Proposal #4-4:**   * When SFN PDSCH is not configured by RRC, for PDSCH reception scheduled by DCI format 1\_0, 1\_1, 1\_2, if the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL,*   + For DCI format 1\_1/1\_2, support both configurations with and without TCI state field.   + If *enableTwoDefaultTCIStates* is not configured, for both cases with and without TCI state field,     - If enhanced SFN PDCCH transmission scheme 1 or TRP based pre-compensation (if supported in FR2) is configured and the lowest CORESET ID in the latest slot is indicated with two TCI states, select the 1st TCI state of the two TCI states of the CORESET as default beam for the PDSCH reception     - Otherwise, UE applies the one active TCI state of the CORESET with the lowest *controlResourceSetId* in the latest slot when receiving the PDSCH * Note that the above agreement doesn’t mean “Combination of scheme-1 + Rel-16 MTRP PDSCH is supported, which is a separate issue   . |

### Issue #4-5 (Additional default TCI for SFN PDSCH and offset smaller than threshold)

Two companies in [5], [16] have mentioned that default TCI is not defined in case of SFN PDSCH is configured, and scheduling offset is smaller than threshold according to the following cases in [5].

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Case** | **SFN PDSCH configured by RRC** | **enableTwoDefaultTCI-States** | **TCI codepoint indicates two TCI states** | **Dynamic switching** | **Default TCI state** |
| 2 | Yes | Configured | None | Support | If the CORESET with the lowest ID in the latest slot is indicated with two TCI states, UE applies both TCI states of the CORESET  Otherwise, UE applies the active TCI state of the CORESET with the lowest ID in the latest slot |
| 3 | Yes | Not configured | / | Support | If the CORESET with the lowest ID in the latest slot is indicated with two TCI states, select the 1st TCI state of the two TCI states of the CORESET  Otherwise, apply the active TCI state of the CORESET with the lowest ID in the latest slot |
| 4 | All | Not support | Error case (UE expects that *enableTwoDefaultTCI-States* is configured) |

It was, therefore, proposed to discuss the following proposals for default TCI state to address the remaining cases.

**Issue #4-5:**

If the time offset between the reception of the DCI and its scheduled PDSCH is less than the threshold *timeDurationForQCL*, SFN PDSCH is configured by RRC and *enableTwoDefaultTCI-States* is configured, [if UE supports the dynamic switching], but there is no TCI codepoint with two TCI states activated by MAC CE, the default TCI state for PDSCH can be determined as follow.

* If the CORESET with the lowest ID in the latest slot is indicated with two TCI states, UE applies both TCI states of the CORESET.
* Otherwise, UE applies the active TCI state of the CORESET with the lowest ID in the latest slot.

If the time offset between the reception of the DCI and its scheduled PDSCH is less than the threshold *timeDurationForQCL*, SFN PDSCH is configured by RRC and *enableTwoDefaultTCI-States* is not configured, [if UE supports dynamic switching], the default TCI state for PDSCH can be determined as follow.

* If the CORESET with the lowest ID in the latest slot is indicated with two TCI states, UE selects the first TCI state of the two TCI states of the CORESET.
* Otherwise, UE applies the active TCI state of the CORESET with the lowest ID in the latest slot.

#### Round-1

**Proposal #4-5:**

* TBD

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Moderator | More inputs from other companies are needed |
| OPPO | One question for clarification: For case 3, if SFN PDSCH is configured, why gNB doesn’t configure *enableTwoDefaultTCI-States* to UE? We think *enableTwoDefaultTCI* should be configured for this case. |
| DOCOMO | We think the proposal 4-5 is low priority than Proposal #4-1/4-2/4-3/4-4, because we think it is corner case.  For case 2, we are fine with the proposal.  For case 3, we assume the previous agreement already covers the proposed case, because the agreement didn’t mention whether SFN PDSCH is configured or not.  **Agreement**  When SFN PDSCH is not configured by RRC, for PDSCH reception scheduled by DCI format 1\_0, 1\_1, 1\_2, if the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL,*   * For DCI format 1\_1/1\_2, support both configurations with and without TCI state field. * [If *enableTwoDefaultTCIStates* is not configured,] for both cases with and without TCI state field,   + If enhanced SFN PDCCH transmission scheme 1 is configured and the lowest CORESET ID in the latest slot is indicated with two TCI states, select the 1st TCI state of the two TCI states of the CORESET as default beam for the PDSCH reception     - FFS: Whether above applies for TRP-based pre-compensation if TRP-based pre-compensation is agreed to be support in FR2   + Otherwise, UE applies the one active TCI state of the CORESET with the lowest *controlResourceSetId* in the latest slot when receiving the PDSCH |
| ZTE | Support |
| Lenovo/MotM | Support in principle. More discussion is also needed on “if UE supports dynamic switching” |
| QC | Don’t support.  Why gNB wouldn’t configure one TCI codepoint with two TCI states when SFN PDSCH is configured? |
| Xiaomi | It is corner case with low priority. |
| LGE | We don’t support the first proposal for case 2. For case 2, we think it is a corner case. It is not clear why gNB configures enableTwoDefaultTCI-States but doesn’t activate TCI codepoint with two TCI states.  For case 3, same view with DOCOMO. |
| vivo | Support, and we would like to try to clarify the case 2 and case 3:  Regarding case 2, when SFN PDSCH is configured by RRC, it is possible that there would be no TCI codepoint with two TCI states. This situation might also happen in Rel-16 MTRP, since there seems no restriction in spec that if Rel-16 MTRP PDSCH is configured, at least one TCI codepoint should be with two TCI states.  Regarding case 3, UE supporting SFN PDSCH might not support to use two default TCI states. |
| CATT | Support. |
| Nokia/NSB | Support. |
| Moderator | Let’s comeback to this issues after 4-1/4-2/4-3/4-4 are finalized. Meanwhile, please continue discussion. |

### Issue #4-6 (Default spatial / PL RS for Rel-17 multi-TRP PUSCH/PUCCH)

Several companies in [4], [5], [16] have mentioned that default spatial relation and PL-RS are only defined in the case of single-TRP PUSCH/PUCCH/SRS transmission. However, for multi-TRP based PUCCH/PUSCH/SRS transmissions, default spatial relation and PL-RS are not defined. It is therefore proposed to clarify default assumptions.

**Issue #4-6:**

**Default beam and PL RS for multi-TRP PUCCH:**

**Alt 1**: When PL-RS and spatial relation information are not configured and default beam is enabled for the PUCCH transmission, if two TCI states are activated for the CORESET with the lowest ID on the active DL BWP,

* If PUCCH repetition is configured, the two TCI states activated for the CORESET with the lowest ID on the active DL BWP are used to determine the spatial relation and PL-RS of PUCCH transmission occasions, and each TCI state is associated to one PUCCH transmission occasion group.

**Alt 2**: A new RRC parameter is introduced to enable two default beams and PL-RSs for PUCCH, and if it is configured:

* when only one TCI state is applied for the CORESET with lowest ID, the TCI state is used as the only default spatial relation and PL-RS for PUCCH transmission.
* when two TCI states are applied for the CORESET with lowest ID, both TCI states are used as two default spatial relations and PL-RSs for PUCCH transmission.

**Default beam and PL RS for multi-TRP PUSCH:**

When the default spatial relation and PL-RS of PUSCH are determined by QCL assumption of CORESET with lowest ID, and two TCI states are activated for the CORESET,

* If PUSCH repetition is configured, the two TCI states activated for the CORESET with the lowest ID are used as the default spatial relation and PL-RS, and each TCI state is associated to one PUSCH transmission occasion group.
* UE does not expect that the network configures two SRS resource sets when applying default beam is enabled

**Default beam and PL RS for multi-TRP SRS:**

When the default spatial relation and PL-RS of SRS are determined by QCL RS of CORESET with lowest ID, and two TCI states are activated for the CORESET,

* If two SRS resource sets for codebook/non-codebook are configured, the two TCI states activated for the CORESET with the lowest ID are used as the default beam and PL-RS of SRS, and each TCI states is associated to one SRS resource set

**Supported by:** ZTE, vivo, Samsung, Mediatek, DOCOMO, CATT, vivo

**Not supported:** OPPO, QC, Xiaomi,

#### Round-1

**Proposal #4-6:**

* + TBD

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| **Company** | **Comment** |
| Moderator | In the last RAN1 meeting several companies proposed to discuss this issue later. Given that this is the last RAN1 meeting for Rel-17, inputs from other companies are needed to finalize the discussion. |
| OPPO | Not support.  For multi-TRP based PUCCH/PUSCH/SRS transmission, whether to apply default spatial relation and PL-RS agreed in Rel-16 has not been agreed even for case of CORESET with single TCI state in 8.1.2.1. We think multi-TRP based PUCCH/PUSCH repetition needs to be configured with two sets of spatial relation information and power control parameters to make it work. If it is not agreed for legacy CORESET in 8.1.2.1, we don’t need to discuss it for enhanced CORESET. |
| DOCOMO | Support the proposal. |
| ZTE | Support the above proposals. We don’t understand the default behavior for STRP is OK why not for MTRP. This feature can achieve MTRP diversity without extra signaling overhead. |
| Lenovo/MotM | For PUCCH, we support Alt 2.  For PUSCH, we think the default beam and pathloss RS should be determined **jointly** by the TCI states of the CORESET with the lowest ID and the 2 bits field which indicates the association SRS resource sets of the PUSCH.  For SRS, we support the proposal. |
| QC | Don’t support. Similar views as OPPO. |
| vivo | Support |
| CATT | Support the proposal. |
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### Issue #4-7 (PDCCH monitoring prioritization 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. Companies’ views on this issue are summarized below.

**Issue #4-7:**

* When a CORESET is activated with two TCI states which overlaps with another CORESET, support PDCCH monitoring of PDCCH candidates in overlapping monitoring occasions with QCL-TypeD properties identified according to prioritization rule
  + Down-select one alternative
    - **Alt 1**: Search Space (SS) type > serving cell index > SS set ID
      * **Supported by:** ZTE, Lenovo / MotMob,
    - **Alt 2**: SS type > serving cell index > SS set ID
      * If prioritized CORESET has one TCI state, the second QCL type D is identified by the first TCI of a CORESET with the secondOP highest priority
      * **Supported by:** Qualcomm, Huawei / HiSilicon, Samsung
    - **Alt 3**: SS type > serving cell index > SS set ID > the number of TCI states of CORESET
      * If prioritized CORESET has one TCI state, the second QCL type D is identified according to one of the SS sets that is linked with a CORESET with the first QCL-TypeD among the multiple overlapping CORESETs); and
      * In case of multiple such CORESETs, Rel. 15 priority order is used for the second QCL-TypeD determination.
      * **Supported by:** Spreadtrum,
    - **Alt 4**: the number of TCI states for CORESET > SS type > serving cell index > SS set ID
      * **Supported by:** NTT DOCOMO (2nd preference)
    - **Alt 5:** SS type > the number of TCI states for CORESET > serving cell index > SS set ID
      * If prioritized CORESET has one TCI state, all CORESETs associated with at least the one active TCI state are also monitored.
      * **Supported by:** LGE, NTT DOCOMO (1st preference), Lenovo / MotMob, LGE, Xiaomi, Samsung,
    - **Alt 6**: SS type > serving cell index > SS set ID > the number of TCI states of CORESET
      * If the firstly prioritized CORESET is associated with one TCI state with QCL-TypeD property, the secondly prioritized CORESET with two TCI states which contains the same QCL-TypeD property with the firstly prioritized CORESET can be monitored. Other CORESETs associated with one or both of these TCI states can also be monitored.
      * If the firstly prioritized CORESET is associated with two TCI states with two QCL-TypeD properties, other CORESETs associated with one or both of these TCI states can also be monitored.
      * **Supported by:** vivo,
    - **Alt 7**: SS type > serving cell index > SS set ID
      * If the prioritized CORESET is associated with only one TCI state corresponding to one QCL-TypeD property, one SFN-ed CORESET including TCI state of this CORESET can be monitored too. Then, other CORESETs that associated with one of or same TCI states as the monitored SFN-ed CORESET can also be monitored.
        + If more than one SFN-ed CORESET include the TCI state of the prioritize CORESET, Rel-15 priority order can be used for the second QCL-TypeD determination.
        + If there is no SFN-ed CORESET includes the TCI state of the prioritize CORESET, another CORESET associated with one TCI state different from the prioritize CORESET can be prioritized secondly. Then other CORESETs that associated with same TCI states as these two prioritized CORESETs can also be monitored.
      * If the prioritized CORESET is associated with two TCI states corresponding to two QCL-TypeD properties, any other CORESETs that have been configured with same QCL-TypeD properties or a subset of these two QCL-TypeD properties as the CORESET can also be monitored.
      * **Supported by:** CATT,
    - **Alt 8**: SS type > serving cell index > SS set ID
      * Reuse legacy priority rule to identify the first QCL-TypeD property, and then, identify the second QCL-TypeD according to one of the CORESETs activated with 2 TCI states, with first QCL-typeD as one of the 2 activated TCI states.
      * In the case of multiple overlapping CORESETs activated with 2 TCI states have a TCI state with a same QCL-typeD as the first QCL-typeD, Rel-15 priority rule is followed for determining oneCORESET from the multiple CORESETs
      * If none of the CORESETs activated with 2 TCI states has a TCI state with a same QCL-typeD as the first QCL-typeD, a second QCL-typeD is not selected.
      * **Supported by:** Ericsson,
    - Note: SS type with CSS has higher priority than SS type with USS, SS set with lower index has higher priority than SS set with higher index, serving cell with lower index has higher priority than serving cell index with higher index, two TCI states for CORESET has higher priority than one TCI state

#### Round-1

**Proposal #4-7:**

* TBD

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| **Company** | **Comment** |
| Moderator | There is no alternative supported by clear majority. Suggest RAN1 to take Alt 1 as possible outcome for this issue, if there is no convergence to other alternative with enhancement. |
| OPPO | We support Alt 1. |
| DOCOMO | Support Alt.5 (1st priority) and Alt.4 (2nd priority).  We don’t support Alt.1, which does not care whether CORESET is indicated with one or two TCI states. We believe CORESET(s) with two TCI states should be higher priority than CORESET(s) with one TCI states, irrespective of the serving cell index or search space index, because CORESET(s) with two TCI states is more suitable for URLLC use-case. |
| ZTE | Listing so many options make issues more complicated.  We think most companies support reusing Rel-15 rule to identify the first CORESET for the first QCL-typeD. If the identified CORESET has two TCI states with QCL-typeD, both QCL-typeD are identified. It is not much contentious.  However, if the identified CORESET has one TCI state, the issue is whether the second CORESET should be identified. We think there are two options. Option 1 is no further to identified the second CORESET, that is only single QCL-typeD is determined. Option 2 is to further find the second QCL-typeD (second CORESET).  Hence, we suggest agreeing the following proposal firstly. In our view, option 1 is simpler. We prefer it.  *Reuse Rel-15 prioritization to identify the first CORESET*   * *If the CORESET has two TCI states with QCL-typeD, both QCL-typeD are identified.* * *If the CORESET has one TCI state with QCL-typeD,*    + *Option 1: the second QCL-typeD is not identified*   + *Opton 2: the second QCL-typeD is identified, FFS details* |
| Lenovo/MotM | We support to reuse legacy priority rule to identify the first QCL-TypeD, i.e. SS type > serving cell index > SS set ID. If another QCL-TypeD is activated in the same CORESET with first identified QCL-TypeD, it can be identified as the second QCL-TypeD. Otherwise, only the first QCL-TypeD is identified |
| QC | We are fine with ZTE proposal. |
| Ericsson | We are fine with ZTE’s proposal. Would like to point out that the main bullet and the first subbullet is aligned with the PDCCH M-TRP agreement on RAN1#106bis. |
| Xiaomi | We are fine with ZTE’s proposal to align with the agreement in 8.1.2.1 |
| LGE | Regarding ZTE’s suggestion, we think the suggestion is only for Alt1/2/3/6/7/8. So, Alt 4 and Alt 5 are not included in the proposal from ZTE. We think it is better to modify ZTE’s suggestion as follow.  *Alt1. Reuse Rel-15 prioritization to identify the first CORESET, i.e., SS type > serving cell index > SS set ID*   * *If the CORESET has two TCI states with QCL-typeD, both QCL-typeD are identified.* * *If the CORESET has one TCI state with QCL-typeD,*    + *Option 1: the second QCL-typeD is not identified*   + *Opton 2: the second QCL-typeD is identified, FFS details*   *Alt2. The number of TCI states for CORESET > SS type > serving cell index > SS set ID*  *Alt3. SS type > the number of TCI states for CORESET > serving cell index > SS set ID* |
| vivo | Fine with ZTE’s revision. |
| Huawei, HiSilicon | Fine with ZTE’s proposal, and we prefer option 1. |
| Spreadtrum | We are fine with ZTE’s proposal. |
| CATT | We also support to reuse legacy priority rule to identify the first CORESET. Besides, for high-reliable transmission, our suggestion is to identify two QCL-TypeD regardless of the TCI state(s) of the first CORESET. |
| Nokia/NSB | Fine with ZTE’s revision. Option is preferred. |
| Moderator | It seems most of the companies are OK with Alt A below.  **Issue #4-7:**  **Option A**: Reuse Rel-15 prioritization to identify the first CORESET i.e., SS type > serving cell index > SS set ID   * If the CORESET has two TCI states with QCL-typeD, both QCL-typeD are identified. * If the CORESET has one TCI state with QCL-typeD,   + Option 1: the second QCL-typeD is not identified   + Option 2: the second QCL-typeD is identified, FFS details   **~~Option B~~**~~: SS type > the number of TCI states for CORESET > serving cell index > SS set ID~~   * ~~If prioritized CORESET has one TCI state, all CORESETs associated with at least the one active TCI state are also monitored.~~   Let’s try to down-select now between Option 1 and Option 2 and more important address FFS. Please continue discussion. |

### Issue #4-8 (CSS associated with SFN CORESET)

In RAN1#106bis-e meeting, the following agreement for CSS associated with SFN CORESET was made:

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| **Agreement**  For CSS associated with SFN CORESET, study the following alternatives and down-select in RAN1#107e:   * Alt 2: UE doesn’t expect PDCCH candidates in CSS to be associated with CORESET activated with two TCI states, except for CSS type 3 associated with CORESET configured with scheme 1 * Alt 3: If PDCCH candidates in CSS 0/0A/1/2/3 are associated with CORESET that activated with two TCI states, the first TCI state is applied for the CSS reception, except for CSS type 3 associated with CORESET configured with scheme 1.   + For CSS type 3 associated with CORESET configured with scheme 1,  both TCI states can be applied for the CSS reception. |

Several companies provided their preference regarding agreed alternatives as well provided some modifications with

**Issue #4-8**: For CSS associated with SFN CORESET

* **Alt 2**: UE doesn’t expect PDCCH candidates in CSS to be associated with CORESET activated with two TCI states, except for CSS type 3 associated with CORESET configured with scheme 1
  + **Supported by:** Spreadtrum, Ericsson, Samsung,
* **Alt 3**: If PDCCH candidates in CSS 0/0A/1/2/3 are associated with CORESET that activated with two TCI states, the first TCI state is applied for the CSS reception, except for CSS type 3 associated with CORESET configured with scheme 1.
  + For CSS type 3 associated with CORESET configured with scheme 1, both TCI states can be applied for the CSS reception.
  + **Supported by:** InterDigital, LGE, NTT DOCOMO, QCM (CSS type 3 is also applicable to TRP based pre-compensation), Mediatek, vivo, CATT, OPPO, Xiaomi, NEC, Lenovo / MotMob
* **New Alt 3a**: if PDCCH candidates in CSS 0/0A/1/2/3 are associated with CORESET that activated with two TCI states,
  + For CSS type 0/0A/2 configured with search space index 0, the monitoring occasions are determined by two SSB indexes associated with the two activated TCI states of the CORESET 0.
  + For CSS type 1, the first TCI state is applied
  + Otherwise, both TCI states can be applied for the CSS reception, i.e. SFN manner
  + **Supported by:** ZTE

There is clear majority that prefers Alt 3 from RAN1#106b-e meeting agreement.

#### Round-1

**Proposal #4-8**:

For CSS associated with SFN CORESET:

* **Alt 3**: If PDCCH candidates in CSS 0/0A/1/2/3 are associated with CORESET that activated with two TCI states, the first TCI state is applied for the CSS reception, except for CSS type 3 associated with CORESET configured with scheme 1.
  + For CSS type 3 associated with CORESET configured with scheme 1, both TCI states can be applied for the CSS reception.

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| **Company** | **Comment** |
| OPPO | Support. |
| DOCOMO | Support. |
| ZTE | Technically, for CSS type 0/0A/2 configured with search space index 0, it will be good if two occasions can be determined based on the configured two TCI states for improving reliability (currently, only single occasion is determined based on the single configured TCI state). So we encourage companies further check the potential enhancement for search space 0. |
| Lenovo/MotM | Support, since it can be used in a scenario in which the CORESET associated with CSS is the same as the CORESET associated with USS with two TCI states for SFN transmission |
| MediaTek | Support |
| QC | We are fine with Alt 3. However, DCI format 1\_0 in CSS 3 can be used for unicast PDSCH. There is no need to exclude sfn scheme B. suggest following edits:  **Alt 3**: If PDCCH candidates in CSS 0/0A/1/2/3 are associated with CORESET that activated with two TCI states, the first TCI state is applied for the CSS reception, except for CSS type 3 ~~associated with CORESET configured with scheme 1~~.   * + For CSS type 3 ~~associated with CORESET configured with scheme 1,~~ both TCI states can be applied for the CSS reception. |
| Ericsson | Do not support. We don’t see advantage with this proposal. CORESET#0 is always configured with one TCI state, and to be used for CSS 0/0A/1/2. |
| Xiaomi | Support |
| LGE | Support. |
| vivo | Support |
| NEC | Support |
| Spreadtrum | In our understanding, CSS type0/0A/1/2 is typically associated with CORESET#0. CORESET#0 is mainly for initial access. There is no need to configure SFN scheme for CORESET#0. |
| CATT | Support. |
| Moderator | **Proposal #4-8a:**   * **Alt 3**: If PDCCH candidates in CSS 0/0A/1/2/3 are associated with CORESET that activated with two TCI states, the first TCI state is applied for the CSS reception, except for CSS type 3 associated with CORESET configured with scheme 1.   + For CSS type 3 associated with CORESET configured with scheme 1, both TCI states can be applied for the CSS reception.   + FFS in RAN1#107e: CSS type 3 associated with CORESET configured with TRP based pre-compensation |

### Issue #4-9 (Broadcast PDSCH scheduled by a PDCCH in CSS)

One company in [8] has mentioned the issue of PDSCH transmission carrying broadcast info. In particular, if the DCI is used to scheduling broadcast information, e.g., scrambled with P-RNTI or SI-RNTI, SFN transmission cannot be applied to the scheduled PDSCH even when the associated CORESET is configured with two TCI states. In this case, one of the TCI states for the CORESETs should be applied to the PDSCH according to the following proposal.

**Issue #4-9**: For PDSCH scheduled by CSS 0/0A/1/2/3, except for CSS type 3 associated with CORESET configured with scheme 1,

* If the scheduling offset is larger than or equal to *timeDurationForQCL*, the first TCI state of the scheduling CORESET is applied for the PDSCH reception
* If the scheduling offset is smaller than *timeDurationForQCL*, the first TCI state of the CORESET with lowest ID in the same BWP is applied for the PDSCH reception
* Note: if only one TCI state is configured for the CORESET, the TCI state is applied to the PDSCH reception.
* Note: For PDSCH scheduled by CSS type 3 associated with CORESET configured with scheme 1, both TCI states can be applied for the PDSCH reception.

#### Round-1

Proposal #4-9:

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs from other companies are needed |
| OPPO | Support. |
| DOCOMO | Support. |
| ZTE | Don’t understand this proposal. In our view, these kinds of broadcast PDSCH is scheduled by DCI format 1\_0 for which default beam behavior has been considered in previous discussion. We don’t need to consider PDSCH scheduled by CSS as a special case. |
| Lenovo/MotM | Support |
| MediaTek | Support |
| Ericsson | Do not support. |
| Xiaomi | Support |
| LGE | We don’t think the proposal is needed.  For the first bullet, it is not clear what is the difference from proposal #4-8.  For the second bullet, same view with ZTE. |
| vivo | It depends on the determination from issue #4-8, we can discuss it after that. |
| Spreadtrum | Not support. This issue is related to issue#4-8. |
| CATT | Support. |
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### Issue #4-10 (UE capability for dynamic switching between SFN and single-TRP)

One company in [22] has mentioned that the previous agreement on definition of UE not capable of dynamic switching should be amended to also include restriction for the CORESET configuration that schedules unicast PDSCH by DCI Format 1\_0 with scheduling offset larger than threshold.

**Issue #4-10:**

For UE not capable of dynamic switching between SFN scheme 1 and single-TRP

* For unicast PDSCH scheduled by DCI format 1\_0 with scheduling offset equal or larger than threshold ‘*timeDurationForQCL*, the UE does not expect the scheduling CORESET to be activated with single TCI states, if UE is configured with SFN scheme by RRC

#### Round-1

Proposal #4-10:

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs from other companies are needed |
| DOCOMO | Not support. Firstly, the dynamic switching capability is only applicable for the dynamic switching by TCI state field.  Secondly, we don’t clearly understand how to operate if the proposal is agreed. It is inevitable for UE to receive DCI format 1\_0 in CSS to schedule PDSCH, even if UE is configured with SFN and not supporting the capability. If the proposal is agreed,   * One CORESET with one TCI state is configured, which is used for dedicated for CSS or DCI format 1\_0 reception to schedule S-TRP PDSCH. * Another CORESET with two TCI state is configured, which is dedicated for USS and DCI format 1\_1/1\_2 reception to schedule SFN-PDSCH.   Is this the intention of the proposal? |
| ZTE | Don’t support his proposal. Dynamic switching between STRP and SFN should be mandated for PDSCH scheduled by DCI 1\_0 as we agreed before. |
| Lenovo/MotM | Support |
| QC | Support. Please view our comment for issue #4-2. |
| Ericsson | Do not support. |
| CATT | Not support. |
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## 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, Radio Link Monitoring

### Issue #5-1 (Number of BLER, number of BFD RS and prioritization of RS for implicit BFD)

Several companies discussed the issues of the BLER calculation from two TCI states, UE capability for number of implicit BFD RS and prioritization of RS for BFD monitoring, when two TCI states are activated for CORESET. Companies’ views for these issues are summarized below.

**Issue #5-1:**

* BLER for BFD RS is calculated according to the following rule. Down-select one alternative:
  + **Alt 1**: For a CORESET with two activated TCI states, two RS indexes are included in and UE calculates two hypothetical BLER for the CORESET
    - **Supported:** Convida,Intel,Spreadtrum
  + **Alt 2**: For a CORESET with two activated TCI states, UE calculates single hypothetical BLER
    - **Supported:** ZTE, vivo, Qualcomm, Apple, OPPO, DOCOMO, Lenovo/MotMob, Mediatek, Xiaomi, LGE, Sony, Huawei/HiSilicon, NEC, CATT, Nokia/NSB
* For the implicit BFD RS, the number of monitored BFD RSs X is UE capability
  + X = 2, 3, 4
    - **Supported**: LGE, DOCOMO (X=4), Nokia/NSB, InterDigital, CATT, Lenovo/MotMob, NEC, CATT
    - **Not supported**: vivo, OPPO, ZTE, Mediatek, QC, Xiaomi, vivo, Sony, Huawei/HiSilicon, Spreadtrum
* The rules for selecting multiple BFD RSs for implicit BFD RS configuration is supported.
  + **Alt 1**: CORESET activated with two TCI states can be detected with higher priority
  + **Alt 2**: UE selects X RS provided for active TCI states for PDCCH receptions in CORESETs associated with the search space sets in an order from the shortest monitoring periodicity. If more than one CORESETs are associated with search space sets having same monitoring periodicity, the UE determines the order of the CORESET from the highest CORESET index. If the CORESET selected based on the above rule is activated with two TCI states, RS in both TCI states are selected for BFD.
  + **Alt 2a**: UE selects X RS provided for active TCI states for PDCCH receptions in CORESETs associated with the search space sets in an order from the shortest monitoring periodicity. If more than one CORESETs are associated with search space sets having same monitoring periodicity, the UE determines the order of the CORESET from the highest CORESET index. If the CORESET selected based on the above rule is activated with two TCI states, it is up to UE implementation to select one RS as BFD-RS.
  + **Alt 3**: When configured with two CORESETs with one or two active TCI States and the number of monitored BFD-RSs is 2, UE selects one RS from one CORESET and one RS from another CORESET. When supporting number of monitored BFD-RSs as 3 or 4 based on UE capability:
    - If all CORESETs are SFN-CORESETs, one BFD RS pair for SFN CORESET is counted as two BFD RSs and remaining one or two BFD-RSs are selected from first TCI state (for X = 3 if supported) or both TCI states (for X = 4 if supported) of SFN CORESET, respectively.
    - If CORESETs are a mix of SFN-CORESET(s) and non-SFN CORESET(s),
      * if X = 3 (if supported), one BFD RS pair for SFN CORESET is counted as two BFD RSs and remaining one BFD-RSs are selected from TCI state of non-SFN CORESET.
      * if X = 4 (if supported), one BFD RS pair for SFN CORESET is counted as two BFD RSs and remaining two BFD-RSs are selected from the TCI state of non-SFN CORESET and one TCI state from the remaining CORESET.
    - **Supported**: DOCOMO, OPPO(2a) Nokia/NSB(3), CATT(3), ZTE(2), Xiaomi (2), QC(2a), Mediatek (2), LGE (1 or 3), vivo (2), Huawei/HiSilicon (2), NEC (1),
    - **Not supported**: Spreadtrum

#### Round-1

Proposal #5-1:

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs from other companies are needed |
| OPPO | First issue: support Alt2  2nd: Not support. The current specification shall be reused.  3rd: ok with Alt2 with a revision: “If the CORESET selected based on the above rule is activated with two TCI states, it is up to UE implementation to select one RS as BFD-RS”. |
| DOCOMO | 1st issue: support Alt.2  2nd issue: support. X=2 means 2 CORESET in Rel.16, however X=4 means 2 CORESET in SFN, based on the previous agreement.  3rd issue: Support. The number of BFD RS is smaller than the number of CORESETs, without the proposal, there is misunderstanding between UE and gNB which BFD-RS should be used. |
| ZTE | 1st : support Alt2  2nd: Support. 2 RS is not enough  3rd: Support Alt 2 without any change |
| Lenovo/MotM | For BLER calculation, we support Alt.2  For the number of monitored BFD RSs, we support X=2, 3, 4.  For rules for selecting multiple BFD RSs for implicit BFD RS configuration, we believe it is related with conclusions of supported number of monitored BFD RSs |
| MediaTek | First: Alt 2  Second: Don’t support. X=2 should be enough  Third: Alt 2 |
| QC | 1st issue: Support Alt 2  2nd issue: Don’t support.  3rd issue: Alt 2 (X=2) and fine with OPPO edits. |
| Xiaomi | 1st issue, support Alt 2  2nd issue, prefer X=2  3rd issue, support Alt 2 with “If the CORESET selected based on the above rule is activated with two TCI states, RS in both TCI states are selected for BFD” |
| LG | 1st: Alt2  2nd: Support, 2 RS is not enough when SFN CORESET exist  3rd: Support. In legacy, we let the BFD RS selection up to UE implementation due to the fact that typical NW would not configure more than two different TCIs across all CORESETs, i.e. it is a corner case. But with SFN CORESET, it is not corner case anymore so a clear rule on the BFD RS selection needs to be defined. Among the listed alts, in general, we should minimize the probability of using only one TCI RS of SFN CORESET since UE cannot calculate hypothetical BLER of the CORESET correctly in such case. In this regard, alt1 or alt3 is preferred. |
| vivo | 1st issue: Support Alt 2  2nd issue: Support X=2  3rd issue: Support Alt 2 with X=2 |
| Huawei, HiSilicon | 1st: Support Alt 2  2nd: Don’t support. X should not be larger than 2.  3rd: We are fine with Alt 2 with X=2. |
| Sony | 1st issue, support Alt 2.  2nd issue, okay with X = 2. |
| NEC | 1st issue: Support Alt 2.  2nd issue: Fine.  3rd issue: prefer Alt 1. |
| Spreadtrum | 1st issue: not clear why we discuss this issue, since we have the following conclusion.  **Conclusion**  No RAN1 specification impact on how to calculate hypothetical BLER for BFD  2nd issue: X=2 seems enough.  3rd issue: reuse the current spec is enough. Suggest to add one new Alt.  Alt4: It is up to UE’s implementation. |
| CATT | 1st issue: support Alt 2.  2nd issue: support.  3rd issue: We support Alt 3 in principle. But if CORESETs are a mix of SFN-CORESET(s) and non-SFN CORESET(s) and X=4, how to determine the remaining BFD-RSs after determining the two prioritized SFN-ed BFD-RSs needs to be further discussed. To address this issue, the following two alternatives can be considered:   * if X = 4, one BFD RS pair for SFN CORESET is counted as two BFD RSs,   + Alt 3-1: The remaining two BFD-RSs are selected from the TCI state of SFN-ed CORESET. If there is no SFN-ed CORESET, the remaining two BFD-RSs are selected from of non-SFN CORESET, the TCI state of one TCI state from the remaining CORESET.   + Alt 3-2: The remaining two BFD-RSs are selected from the TCI state of non-SFN CORESET and one TCI state from the remaining CORESET. |
| Nokia/NSB | 1st issue: Support Alt 2  2nd issue: Support.  3rd issue: Support Alt 3. |
| Moderator | **Proposal #5-1:**   * BLER for BFD RS is calculated according to the following rule.   + **Alt 2**: For a CORESET with two activated TCI states, UE calculates single hypothetical BLER   + Note: how to calculate hypothetical BLER for BFD is up to UE implementation * (For conclusion) For the implicit BFD RS, possible definition of new UE capability for the number of monitored BFD RSs to be discussed in UE capability session * The rules for selecting multiple BFD RSs for implicit BFD RS configuration is supported. Down-select one alternative in RAN1#107b   + **Alt 2**: UE selects X RS provided for active TCI states for PDCCH receptions in CORESETs associated with the search space sets in an order from the shortest monitoring periodicity. If more than one CORESETs are associated with search space sets having same monitoring periodicity, the UE determines the order of the CORESET from the highest CORESET index. If the CORESET selected based on the above rule is activated with two TCI states, RS in both TCI states are selected for BFD.   + **Alt 3**: When configured with two CORESETs with one or two active TCI States and the number of monitored BFD-RSs is 2, UE selects one RS from one CORESET and one RS from another CORESET. When supporting number of monitored BFD-RSs as 3 or 4 based on UE capability if supported:     - If all CORESETs are SFN-CORESETs, one BFD RS pair for SFN CORESET is counted as two BFD RSs and remaining one or two BFD-RSs are selected from first TCI state (for X = 3 if supported) or both TCI states (for X = 4 if supported) of SFN CORESET, respectively.     - If CORESETs are a mix of SFN-CORESET(s) and non-SFN CORESET(s),       * if X = 3 (if supported), one BFD RS pair for SFN CORESET is counted as two BFD RSs and remaining one BFD-RSs are selected from TCI state of non-SFN CORESET.       * if X = 4 (if supported), one BFD RS pair for SFN CORESET is counted as two BFD RSs and remaining two BFD-RSs are selected from the TCI state of non-SFN CORESET and one TCI state from the remaining CORESET.   Please continue discussion. |

### Issue #5-2 (Explicit RS configuration for BFD)

Several companies have discussed the issue of explicit RS configuration for BFD based on the agreement from RAN1#105-e meeting.

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| **Agreement**  If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP-based pre-compensation) is configured and two TCI states are activated for at least one 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 * Note: down-selection can be done separately for Rel-15/16 cell specific BFR and Rel-17 TRP-specific BFR, Rel-17 TRP-specific BFR to be discussed under AI 8.1.2.3 |

**Issue #5-2:**

If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP-based pre-compensation) is configured and two TCI states are activated for at least one CORESET, support the following configuration of RS for BFD

* + **Alt 2-1**: Support defining CSI-RS resource or SSB pairs as BFD RS
    - FFS other details
    - **Supported by (9)**: ZTE, CATT, Xiaomi, Lenovo / MotMob, Apple, DOCOMO, Xiaomi, Sony, NEC,
  + **Alt 2-2**: Reuse the existing Rel-15/Rel-16 approach for BFD RS configuration
    - **Supported by (10)**: Convida, Qualcomm, Intel, OPPO, Mediatek, LGE, vivo, Huawei / HiSilicon, Spreadtrum, Nokia/NSB

#### Round-1

**Proposal #5-2:**

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs from other companies are needed |
| OPPO | Prefer Alt2-2, the rel15/16 method is reused. |
| DOCOMO | Support Alt.2-1. |
| ZTE | Support 2-1 for more flexibility |
| Lenovo/MotM | Support Alt 2-1, assuming hypothetical BLER calculation based on SFN transmission. Otherwise, the false alarm rate may be higher if hypothetical BLER is calculated based on only one CSI-RS or SSB. If Rel-15/16 like BFD RS configuration is used, some linkage is needed between two BFD RS for SFN transmission |
| MediaTek | Support Alt 2-2 |
| QC | Support Alt 2-2. |
| Xiaomi | Support Alt 2-1 and share same view as Lenovo/MotM |
| LGE | Support Alt 2-2. If BFD RS selection rule is defined, the necessity of defining CSI-RS/SSB pair is unclear. |
| vivo | Support Alt 2-2 |
| Huawei, HiSilicon | Support Alt 2-2 |
| Sony | Support Alt 2-1.  Similar view with Lenovo that the BFD RS relates to the 1st issue of Issue 5.1. If one BLER is calculated for SFN mode, then it seems straight ward to define BFD RS pair(s). |
| NEC | Prefer Alt 2-1. |
| Spreadtrum | Support Alt 2-2 |
| CATT | Support Alt 2-1. |
| Nokia/NSB | Support Alt 2-2. |
| Moderator | **Proposal #5-2 (for conclusion):**  If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP-based pre-compensation) is configured and two TCI states are activated for at least one CORESET, support the following configuration of RS for BFD   * + **Alt 2-2**: Reuse the existing Rel-15/Rel-16 approach for BFD RS configuration |

### Issue #5-3 (NBI RS configuration)

Several companies have provided preference on configuration of new beam identification (NBI) reference signals based on the alternatives from RAN1#106b-e meeting.

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| **Agreement**  When two TCI states are activated for a CORESET, NBI RS can be configured as follows   * **Alt 4-1**: Using the existing Rel-15 NBI configuration based on single SSB / CSI-RS resource * **FFS addition support of** **Alt 4-2**: two new beam identification CSI-RS resource sets / new beam identification CSI-RS resource pairs or SSB pairs |

**Issue #5-3:**

When two TCI states are activated for a CORESET, NBI RS can be also configured using Alt 4-2

* Two new beam identification CSI-RS resource sets / new beam identification CSI-RS resource pairs or SSB pairs
* **Supported**: InterDigital, ZTE, Nokia/NSB, Xiaomi (for SCell?), NEC, Lenovo / MotMob, DOCOMO
* **Not supported:** vivo, Mediatek, Convida, OPPO, QC, LGE, vivo, Huawei / HiSilicon, Sony, Spreatrum, CATT,

#### Round-1

**Proposal #5-3:**

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs from other companies are needed |
| OPPO | Do not support configuring two new beam RS sets. |
| DOCOMO | After BFR, in order to recover to SFN-PDSCH operation, it is needed to report the two NBIs, otherwise UE will fall back to Single TRP PDSCH after BFR. |
| ZTE | Support two new beams for more flexibility |
| Lenovo/MotM | Support two new beam identification CSI-RS resource sets / new beam identification CSI-RS resource pairs or SSB pairs to improve transmission reliability for later PDCCH/PDSCH with SFN-based transmission. This can provide the flexibility for UE to report one or two beams. |
| MediaTek | Don’t support |
| QC | Do not support. UE should recover with single TRP first. |
| Xiaomi | Support. It can recover the SFN PDCCH as soon as possible. It is similar as TRP specific BFR in which at most two qnew can be reported for two TRPs. |
| LGE | Don’t support. |
| vivo | Do not support |
| Huawei, HiSilicon | Don’t support. |
| Sony | Not support.  We think it’s fine for UE to recover to single-TRP mode. In addition, if two new beams are reported, RAN1 then have to decide which new beam out of the two reported beams would be applied for UL, i.e. PUCCH in this case. |
| NEC | Support |
| Spreadtrum | Not support |
| CATT | Not support. |
| Nokia/NSB | Support. |
| Moderator | It seems hard to make agreement on additional support of Alt 4-2 |

### Issue #5-4 (Applicability of the BFR enhancements)

In RAN1#106b-e meeting applicability of beam failure enhancements for different BFD procedures was discussed when two TCI states are activated for CORESET. The following proposal was made in the summary document.

**Issue #5-4:**

When two TCI states are activated for a CORESET, BFR enhancements are applicable to

* CBRA/CFRA based BFR on SpCell in Rel.15.
* BFR MAC CE based BFR on SCell in Rel.16.
* CBRA BFR on SpCell (with BFR MAC CE on Msg.3/A) in Rel.16.

The following proposal is made.

#### Round-1

**Proposal #5-4:**

When two TCI states are activated for a CORESET, BFR enhancements are applicable to

* CBRA/CFRA based BFR on SpCell in Rel.15.
* BFR MAC CE based BFR on SCell in Rel.16.
* CBRA BFR on SpCell (with BFR MAC CE on Msg.3/A) in Rel.16.

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| **Company** | **Comment** |
| OPPO | We shall first discuss issue5-1~3 before discussing this issue.  The outcome and decision made in first 3 issue could affect the applicability of BFR enhancement. For instance, some enhancement might be applicable only for MAC CE based SCell BFR. |
| DOCOMO | Support to cover all cases. |
| ZTE | Support FL proposal |
| Lenovo/MotM | Support |
| MediaTek | Support |
| Xiaomi | Support |
| LG | If the enhancements are limited for BFD only, we are fine with the proposal |
| vivo | Support |
| Sony | Agree with FL’s assessment that this issue highly depends on how we are going to solve above related issues. |
| NEC | Support |
| Spreadtrum | Support |
| CATT | Support. |
| Nokia/NSB | Support. |

### Issue #5-5 (Details of RLM for SFN PDCCH)

Two companies in [16], [20] raised several issues of RLM RS set configuration for enhanced SFN transmission scheme of PDCCH.

**Issue #5-5:**

* For RLM, when RLM RS set is not explicitly provided, for a CORESET indicated with two TCI states, RSs in both TCI states are used as RLM RS
  + **Supported by**: NTT DOCOMO
* For RLM, when RLM RS set is explicitly provided, for a CORESET indicated with two TCI states, study how to ensure the RLM RS includes RSs in both TCI states of a CORESET.
  + **Supported by**: NTT DOCOMO
* Study whether/how to enhance RLM RS selection rule considering CORESET activated with two TCI states
  + **Supported by**: Samsung

#### Round-1

**Proposal #5-5:**

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs from other companies are needed including details for the second and third bullets. |
| DOCOMO | Support the proposal. The discussion points are almost the same as BFD RS. We believe it is important to discuss how RLM works in SFN scenario. |
| ZTE | Can be discussed in CR state considering there are many more important issues to be solved. |
| Lenovo/MotM | We are fine with more discussion on details. |
| MediaTek | Support in principle. |
| QC | Discuss it later in the meeting or in CR state as suggested by ZTE. |
| Xiaomi | We are fine to discuss it |
| LG | Support in principle. We prefer to align BFD RS selection rule (if supported) in #5-1 and RLM RS selection rule as much as possible. As commented in #5-1, we should minimize the probability of using only one TCI RS of SFN CORESET since UE cannot calculate hypothetical BLER of the CORESET correctly in such case. |
| NEC | Fine to discuss. |
| Spreadtrum | Reuse current spec seems to be enough. |
| CATT | Support. |

## Issue #6-1 (Other non-categorized proposals)

* *TRP-specific timing offset pre-adjustment can be considered to further enhance the performance of HST-SFN transmission.*
* *Support RRC signaling to configure two PTRS ports when PDSCH/PDCCH configured with SFN scheme 1 or gNB Doppler pre-compensation, and to introduce one additional resourceElementOffset.*
* *For PDSCH transmitted with Rel-17 HST-SFN scheme 1,* 
  + - *Restricting the DMRS ports of the PDSCH within one CDM group;*
    - *New tables for antenna port indication within one CDM group are supported.*
* *To further facilitate HST-SFN operation, support to extend the QCL assumption of PDCCH/PDSCH DMRS from its serving cell(s) to non-serving cell(s).*
* *NW should explicitly configure or implicitly indicate to UE from which TRP the frequency-domain QCL assumption can be ignored.*
* *UE may assume the CSI-RS and ePDCCH DM-RS port transmitted in monitored search space set(s) associated with CORESET(s) are quasi co-located with 'QCL-TypeD', if applicable, where the 'QCL-TypeD' can be derived from indicated TCI state or default TCI state*

# Other issues

This section contains other issues the companies want to highlight.

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| **Company** | **Comment** |
| vivo | Revising the following agreement achieved in the previous meeting  **Agreement**  If CSI-RS other than those configured with repetition set to 'on' is overlapping in the time domain with CORESET with two TCI states, support the first TCI state of the CORESET as the default TCI assumption for the CSI-RS.  as:  **Agreement**  If CSI-RS other than those configured with repetition set to 'on' is overlapping in the time domain with CORESET with two TCI states, support the first TCI state of the CORESET is the same as the ~~default~~ TCI assumption for the CSI-RS.  Reason  The following is specified behaviour in Rel-16 spec 38.214:  For a CSI-RS resource associated with a NZP-CSI-RS-ResourceSet with the higher layer parameter repetition set to 'on', the UE shall not expect to be configured with CSI-RS over the symbols during which the UE is also configured to monitor the CORESET, while for other NZP-CSI-RS-ResourceSet configurations, if the UE is configured with a CSI-RS resource and a search space set associated with a CORESET in the same OFDM symbol(s), the UE may assume that the CSI-RS and a PDCCH DM-RS transmitted in all the search space sets associated with CORESET are quasi co-located with 'typeD', if 'typeD' is applicable. This also applies to the case when CSI-RS and the CORESET are in different intra-band component carriers, if 'typeD' is applicable. Furthermore, the UE shall not expect to be configured with the CSI-RS in PRBs that overlap those of the CORESET in the OFDM symbols occupied by the search space set(s).  From the motivation of the above agreement, it was mainly to handle the situation when CSI-RS other than those configured with repetition set to 'on' is overlapping in the time domain with CORESET with two TCI states. However, the description of “the first TCI state of the CORESET as the default TCI assumption” is not appropriate considering the description in 38.214, because this is not a default beam issue, but an issue to guarantee the same beam for CSI-RS and PDCCH. Therefore, in order to not cause the confusion, we suggest to revise the above agreement to reflect the real meaning more clearly and keep the similar description as what in Rel-16 spec 38.214. |
| Moderator | It depends how editor captures the above agreement. Suggest discussing this issue in CR stage if needed. |
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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] R1-2110765, On M-TRP Operation for HST-SFN Deployment, InterDigital, Inc.

[3] R1-2110785, Enhancements on HST multi-TRP deployment in Rel-17, Huawei, HiSilicon

[4] R1-2110952, Discussion on Multi-TRP HST enhancements, ZTE

[5] R1-2110994, Remaining issues on HST-SFN schemes, vivo

[6] R1-2111088, Discussion on enhancements on HST-SFN deployment, Spreadtrum Communications

[7] R1-2111225, Remaining issues on HST-SFN deployment, CATT

[8] R1-2111283, Enhancements on HST-SFN deployment, OPPO

[9] R1-2111383, Enhancements HST-SFN deployment, Sony

[10] R1-2111457, Enhancements on HST-SFN deployment, LG Electronics

[11] R1-2111480, Enhancements to HST-SFN deployments, Intel Corporation

[12] R1-2111544, Enhancements on HST-SFN deployment, Xiaomi

[13] R1-2111601, Enhancements on HST-SFN deployment, CMCC

[14] R1-2111668, Remaining issues on HST-SFN enhancements, Ericsson

[15] R1-2111687, Discussion on HST-SFN deployment, NEC

[16] R1-2111721, Enhancements on HST-SFN, Samsung

[17] R1-2111857, Views on Rel-17 HST enhancement, Apple

[18] R1-2111940, Enhancements for HST-SFN deployment, Lenovo, Motorola Mobility

[19] R1-2112028, On Enhancements for HST-SFN deployment, Convida Wireless

[20] R1-2112093, Discussion on HST-SFN deployment, NTT DOCOMO, INC.

[21] R1-2112180, Enhancements for HST-SFN deployment, Nokia, Nokia Shanghai Bell

[22] R1-2112200, Enhancements on HST-SFN deployment, Qualcomm Incorporated

[23] R1-2112279, Enhancements on HST-SFN deployment, MediaTek Inc.

# Appendix (Summary of the agreements)

The agreements made in RAN1#102e, RAN1#103e and RAN1#104e, RAN1#105e 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 |

**RAN1#105-e meeting**

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| **Agreement**  Confirm the following 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.  **Agreement**  UE is not expected to be indicated by MAC CE with 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 single-TRP by TCI state field in DCI Format 1\_1/1\_2  **Agreement**  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   + UE is not expected to be indicated by MAC CE with single TCI state per any of TCI codepoint , if UE is configured with TRP-based frequency PDSCH by RRC , but not capable to support dynamic switching between TRP-based frequency and single-TRP by TCI state field in DCI Format 1\_1/1\_2 * 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)   **Agreement**  Enhanced MAC CE signaling is not applicable to any of the configured CORESETs in a BWP if the CORESETs are configured with different *CORESETPoolindex* values in the BWP.  **Working Assumption**  For TRP-based pre-compensation, Variant A (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.   * FFS: Additional support of Variant B   **Agreement**   * 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 * UE does not expect to be configured different SFN schemes (scheme 1 or TRP pre-compensation) for both PDCCH and PDSCH.   + FFS whether this restriction is per UE or per CC * UE does not expect to be configured different SFN schemes (scheme 1 or TRP pre-compensation) for different CORESETs.   + FFS whether this restriction is per UE or per CC   **Agreement**  Enhanced SFN PDCCH transmission scheme (scheme 1 or TRP-based pre-compensation) is identified by the number of TCI states activated per CORESET and RRC parameter   * FFS: Configuration detail of RRC parameter   + Including whether the same RRC parameter is used for PDCCH and PDSCH   **Agreement**  If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP -based pre-compensation) is configured and a CORESET is activated 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, down-select rule to determine default beam(s) for Rel-17 SFN PDSCH reception in RAN1#106-e:   * **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   **Agreement**  If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP-based pre-compensation) is configured and two TCI states are activated for at least one 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 * Note: down-selection can be done separately for Rel-15/16 cell specific BFR and Rel-17 TRP-specific BFR, Rel-17 TRP-specific BFR to be discussed under AI 8.1.2.3 |

**RAN1#106e meeting**

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| **Agreement**  Support the following combination of the transmission schemes   * Single-TRP PDCCH + Rel-17 Scheme 1 PDSCH * Single-TRP PDCCH + Rel-17 TRP-based pre-compensation PDSCH * FFS: Other combinations of the transmission scheme   Note: The PDSCH corresponds to the PDSCH scheduled by DCI formats 1\_1 and 1\_2.  **Agreement**  For Rel-17 TRP-based pre-compensation scheme, indication of carrier frequency for uplink transmission (Doppler frequency reporting) in TRP-based pre-compensation scheme is supported using   * **Option 1** Implicit from RAN1#102-e agreement   + FFS enhancements to SRS (e.g multiple SRS resource in a set) to improve the accuracy of frequency estimation   For Option1, some companies raised concerns that there is no consensus on the benefit and the applicability of this scheme in FDD.  For Option1, some companies raised concerns that there is no benefit in low SNR scenarios.  **Agreement**  For TRP -based pre-compensation   * Alt-1: QCL parameters are dropped from the second TCI state of the indicated TCI codepoint containing two TCI states   **Conclusion**  For Variant A and B (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   **Agreement**  Confirm working assumption from RAN1#105e meeting without modification:  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.   * FFS: Support of Variant B   **Agreement**  In CA scenario support RRC configured set of the serving cells which can be addressed by a single MAC CE for activation of two TCI states of CORESET with the same CORESET ID for all the BWPs in the indicated CCs set   * FFS: Whether to reuse Rel-16 RRC parameters or introduce new RRC parameters. * FFS: UE capability * FFS: Whether/How to update the CORESET that is not configured to SFN scheme in the indicated CCs set   **Agreement**  If enableTwoDefaultTCI-States is configured and at least one TCI codepoint indicates two TCI states and time offset between the reception of the DL DCI and the PDSCH is less than the threshold timeDurationForQCL, default beam(s) for Rel-17 enhanced SFN PDSCH (scheme 1 or if supported TRP-based pre-compensation) reception:   * **Alt 1**: Reuse rule to determine TCI states as defined for Rel-16 PDSCH scheme-1a   This is a UE optional feature  **Agreement**  For PDSCH reception scheduled by DCI format 1\_0, [1\_1 and 1\_2], if the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL*   * Support configuration when there is no TCI field in the DCI scheduling PDSCH   + UE applies the state(s) of the scheduling CORESET when receiving the PDSCH     - if there are two active TCI states for the CORESET, UE applies the both QCL assumption of the CORESET that schedules the PDSCH when receiving the PDSCH     - otherwise, UE applies the one active TCI state of the CORESET when receiving the PDSCH * FFS if the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL*   This is a UE optional feature.  **Agreement**  If enhanced SFN PDCCH transmission scheme (scheme 1 or if TRP-based pre-compensation is supported in FR2) is configured and 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 DL signal on the same symbol, use one of two TCI states as default beam for aperiodic CSI-RS reception, i.e.   + using one TCI state of the CORESET with the lowest CORESET ID in the latest slot as default beam for aperiodic CSI-RS reception. If there are two activated TCI states for the CORESET with the lowest CORESET ID, one of two TCI states will be selected, i.e. always selects the first TCI state if the CORESET has two TCI states * If there is other DL signal on the same symbol, reuse Rel-15/16 mechanism   **Agreement**  If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP-based pre-compensation) is configured and two TCI states are activated for at least one CORESET, support the following configuration of RS for BFD   * For implicit configuration   + **Alt 1-2**: RS of CORESETs with both single and two TCI states are used   FFS: The maximum number of BFD RS and details on RS determination  **R1-2108548** Summary#3 of AI: 8.1.2.4 Enhancements on HST-SFN deployment Moderator (Intel Corporation)  **Agreement**  If enhanced SFN PDCCH transmission scheme (scheme 1 or if TRP-based pre-compensation is supported in FR2) is configured, and if the CORESET with the lowest ID in the active DL BWP is indicated with two TCI states   * If PL-RS and spatial relation information are not configured for PUCCH and enableDefaultBeamPL-ForPUCCH is configuredin FR2   + For single-TRP PUCCH transmission, select the first TCI state of the CORESET as default beam and PL RS * If PUSCH scheduled by DCI format 0\_0 and *enableDefaultBeamPL-ForPUSCH0-0* is configured in FR2, and if PUCCH resource is not configured on active UL BWP in the cell or if spatial relation is not configured in any PUCCH resource on active UL BWP in the cell,   + For single-TRP PUSCH transmission scheduled by DCI format 0\_0, select the first TCI state of the CORESET as default beam and PL RS * If PL-RS and spatial relation information are not configured for SRS and *enableDefaultBeamPL-ForSRS* is configured in FR2   + For single-TRP SRS resource, select the first TCI state of the CORESET as default beam and PL RS * FFS other details, if any * These are UE optional features   **Agreement**  When a CORESET is activated with two TCI states which overlaps with another CORESET, support extension of Rel-15 prioritization rule for PDCCH monitoring of PDCCH candidates in overlapping monitoring occasions with different QCL-TypeD   * FFS: Prioritization rule considers CORESETs indicated with 1 and/or 2 TCI states * Supports identifying two QCL-TypeD properties for multiple overlapping CORESETs   + UE capability is introduced * FFS other details * FFS: Strive to have same / similar solution as discussed under AI 8.1.2.1   **Conclusion**  No RAN1 specification impact on how to calculate hypothetical BLER for BFD |

**RAN1#106b-e meeting**

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| **Working Assumption**  Reuse legacy Rel-16 RRC parameters *simultaneousTCI-UpdateList1, simultaneousTCI-UpdateList2* to define set of the serving cells which can be addressed by a single MAC CE for activation of two TCI states of CORESET with the same CORESET ID for all the BWPs.  **Agreement**  If CSI-RS other than those configured with repetition set to 'on' is overlapping in the time domain with CORESET with two TCI states, support the first TCI state of the CORESET as the default TCI assumption for the CSI-RS.  **Agreement**  Support combination of Rel-17 SFN PDCCH scheme 1 and single-TRP PDSCH   * This is optional UE feature * Note: The support of such combination scheme is for URLLC use-case only.   **Agreement**  Enhanced SFN (scheme 1 or TRP-based pre-compensation scheme) for PDCCH and PDSCH is configured by using separate per-BWP RRC parameters   * In Rel-17, all downlink BWPs (except initial BWP and FFS: BWP-DownlinkCommon) within a CC should be the same configuration of SFN scheme   **Agreement**  When SFN PDSCH is not configured by RRC, for PDSCH reception scheduled by DCI format 1\_0, 1\_1, 1\_2, if the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than the threshold *timeDurationForQCL,*   * For DCI format 1\_1/1\_2, support both configurations with and without TCI state field. * [If *enableTwoDefaultTCIStates* is not configured,] for both cases with and without TCI state field,   + If enhanced SFN PDCCH transmission scheme 1 is configured and the lowest CORESET ID in the latest slot is indicated with two TCI states, select the 1st TCI state of the two TCI states of the CORESET as default beam for the PDSCH reception     - FFS: Whether above applies for TRP-based pre-compensation if TRP-based pre-compensation is agreed to be support in FR2   + Otherwise, UE applies the one active TCI state of the CORESET with the lowest *controlResourceSetId* in the latest slot when receiving the PDSCH   **Agreement**  For CSS associated with SFN CORESET, study the following alternatives and down-select in RAN1#107e:   * Alt 2: UE doesn’t expect PDCCH candidates in CSS to be associated with CORESET activated with two TCI states, except for CSS type 3 associated with CORESET configured with scheme 1 * Alt 3: If PDCCH candidates in CSS 0/0A/1/2/3 are associated with CORESET that activated with two TCI states, the first TCI state is applied for the CSS reception, except for CSS type 3 associated with CORESET configured with scheme 1.   + For CSS type 3 associated with CORESET configured with scheme 1,  both TCI states can be applied for the CSS reception.     **Agreement**  When CORESET is indicated with two TCI states   * One BFD RS pair for SFN CORESET is counted as two BFD RSs * FFS: Increase the maximum number of monitored BFD RSs to X.   + X is UE capability   + X = 2, 3, 4, FFS other values of X   **Agreement**  When two TCI states are activated for a CORESET, NBI RS can be configured as follows   * **Alt 4-1**: Using the existing Rel-15 NBI configuration based on single SSB / CSI-RS resource * **FFS addition support of** **Alt 4-2**: two new beam identification CSI-RS resource sets / new beam identification CSI-RS resource pairs or SSB pairs |