**3GPP TSG RAN WG1 #108-e R1-220xxxx**

**e-Meeting, February 21st – March 3rd, 2022**

**Source: Moderator (Intel Corporation)**

**Title: Summary#1 of AI: 8.1.2.4 Maintenance on enhancements for HST-SFN deployment**

**Agenda item: 8.1.2.4**

**Document for: Discussion and Decision**

# Introduction

The document contains summary of maintenance issues and text proposals (TPs) on enhancements for HST-SFN deployment.

# Maintenance issues

## Issues related to new agreements

### Issue #1-1 (SFN CORESET before reception of MAC-CE)

One company (Qualcomm [15]) has noted that in Rel-15 MAC CE signaling is not mandatory when UE’s CORESET is configured with only one TCI state. It was proposed to extend the principle to Rel-17, where 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.

#### Round-1

**Proposal #1-1:**

* 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 QCLed with the DL RSs in the two TCI states

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| **Company** | **Comment** |
| Moderator | This issue has been discussed in the previous meeting. Meanwhile companies are welcome to provide their views on this issue. |
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### Issue #1-2 (MAC-CE for CORESET 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 corresponding issue was discussed in several meetings, but not agreement was made. In this meeting several companies (CATT [5], CMCC [11], Lenovo / MotMobility [14], Qualcomm [15],…) have made the following proposals corresponding to Alt 1 and Alt 2.

**Issue #1-2:**

* Alt 1: If single MAC-CE activates two TCI states for CORESETs in a CC/serving cell set. For CCs not configured with SFN, 1st TCI state of the two indicated TCI states is selected.
	+ **Supported by**: NTT DOCOMO, CATT, Lenovo / MotMobility
* 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
	+ **Supported by**: ZTE, Nokia / NSB, Qualcomm, CMCC, OPPO, MediaTek, Sony, Ericsson, Xiaomi, LGE, vivo, Huawei / HiSilicon, Sony, Spreadtrum, Nokia/NSB, Intel

#### Round-1

**Proposal #1-2:**

* UE doesn’t expect to receive a MAC-CE activating two TCI states for a CORESET that is not configured with SFN scheme.

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| **Company** | **Comment** |
| Moderator | This issue has been discussed in the previous meeting. However due to lack of time was not finalized. Based on the companies’ preference indicated in the last RAN1 meeting, Alt 1 is selected for proposal. |
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### Issue #1-3 (Default beam for PDSCH when time offset less than threshold)

Several companies (vivo [2], DOCOMO [6], Samsung [13], Nokia/NSN [16]) have discussed the issues of default beam assumption for PDSCH reception when time offset is less then threshold. In particular, it was noted that that the cases listed in the table below were not addressed by the previous agreements.

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| **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 |

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| **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 CORESETOtherwise, 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 CORESETOtherwise, 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 proposals 1-2 to finalize them.

**Proposal 1:**

When SFN PDSCH is configured by RRC (regardless of whether SFN PDCCH is configured or not), *enableTwoDefaultTCI-States* is configured and there is no TCI codepoint with two TCI states activated by MAC CE, the time offset between the reception of the DCI and its scheduled PDSCH is less than the threshold *timeDurationForQCL*, the default TCI state for PDSCH is determined as follows

* If enhanced SFN PDCCH transmission scheme 1 or TRP-based pre-compensation is configured and the lowest CORESET ID in the latest slot is indicated with two TCI states, UE applies both TCI states of the CORESET
* Otherwise, UE applies the one active TCI state of the CORESET with the lowest ID in the latest slot
* FFS whether it is optional feature

**Proposal 2:**

When SFN PDSCH is configured by RRC (regardless whether SFN PDCCH is configured or not) and *enableTwoDefaultTCI-States* is not configured and the time offset between the reception of the DCI and its scheduled PDSCH is less than the threshold *timeDurationForQCL*, the default TCI state for PDSCH is determined as follows

* For DCI format 1\_1/1\_2, support both configurations with and without TCI state field.
* If enhanced SFN PDCCH transmission scheme 1 is configured and the CORESET with the lowest ID in the latest slot is indicated with two TCI states, UE applies the 1st TCI state of the two TCI states of the CORESET as default beam for PDSCH reception
* Otherwise, UE applies the one active TCI state of the CORESET with the lowest ID in the latest slot

One company (vivo [2]) has been also proposed to introduce additional NW configuration requirements for *enableTwoDefaultTCI-States* parameter for UE not capable of dynamic switching between sTRP and SFN and PSDCH scheduling offsets less than threshold.

**Proposal 3:**

When SFN PDSCH is configured by RRC, if UE is not capable of dynamic switching between STRP and SFN transmission and the time offset between the reception of the DCI and its scheduled PDSCH is less than the threshold timeDurationForQCL, UE expects that enableTwoDefaultTCI-States is configured.

One company (Ericsson [9]) has also mentioned that the agreement mentioned in the beginning of section only covers UE behavior for PDSCH reception when DCI 1\_1/1\_2 is configured with TCI field and suggested to address the remaining cases highlighted in the table below.

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| Time offset between DCI and PDSCH | DCI 1\_0 | DCI 1\_1/1\_2 with “tci-PresentInDCI” enabled | DCI 1\_1/1\_2 with “tci-PresentInDCI” disabled |
| < threshold | No agreement | Yes | No agreement |

**Proposal 4:**

* If single-TRP PDCCH and SFN PDSCH is configured, for PDSCH scheduled by DCI Format 1\_0, if the time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*, UE applies the activated TCI state of the CORESET with the lowest CORESET ID in the latest slot when receiving the PDSCH.
* If single-TRP PDCCH and SFN PDSCH is configured, for PDSCH scheduled by DCI Format 1\_1/1\_2, if the time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*,
	+ For configuration without TCI field, UE applies the activated TCI state of the CORESET with the lowest CORESET ID in the latest slot when receiving the PDSCH.

#### Round-1

**Proposal #1-3:**

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| **Company** | **Comment** |
| Moderator | Proposals 1, 2 were discussed in the previous meeting, but due to lack of time, the discussion was not finalized although some concerns were raised. Further inputs on these proposals and additional proposals 3, 4 are needed. |
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### Issue #1-4 (Default beam for PDSCH when time offset larger than threshold)

In the RAN1#107e meeting default beam for PDSCH reception was agreed when SFN is configured for both PDCCH and PDSCH. It was also agreed to support the configuration when TCI field is not present in the DL DCI when the scheduling offset is equal or larger than the threshold. One remaining issue is the scenario when SFN is configured for PDSCH only and whether TCI field should be always present in this case.

**Issue #1-4:**

* When SFN is configured for PDSCH and not configured for PDCCH:
* **Option 1**: TCI field should be always present in DCI formats 1\_1 and 1\_2 for PDSCH transmission with scheduling offset larger than threshold *timeDurationForQCL*
	+ FFS whether the above assumption is applicable for UE not capable of dynamic switching

**Supported by**: Qualcomm, OPPO, Nokia / NSB

* **Option 2a**: Support configuration without TCI field. If TCI field is not configured and the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL* if applicable*,* UE applies the TCI state of the scheduling CORESET when receiving the PDSCH
	+ FFS whether the above assumption is applicable for UE capable of dynamic switching

**Supported by**: ZTE, HW/HiSi, CATT, Samsung, Lenovo / MotMobility

* **Option 2b**: Support configuration without TCI field. If TCI filed is not configured and the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL* if applicable, UE applies the lowest TCI codepoint with two different TCI states in the activated PDSCH TCI state list for PDSCH reception scheduled by DCI formats 1\_1 and 1\_2

**Supported by**: DOCOMO, Intel, E///

#### Round-1

**Proposal #1-4:**

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| **Company** | **Comment** |
| Moderator | The corresponding issue has been agreed for discussion in the maintenance session. More inputs from other companies are needed. |
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### Issue #1-5 (UE not capable of sTRP / SFN dynamic switching)

One company (Qualcomm [15]) has mentioned that in the RAN1#106-e meeting, it was agreed that PDSCH scheduled by DCI format 1\_0 follow the QCL assumption of the scheduling CORESET, if the time offset is equal or larger than the threshold *timeDurationForQCL.* However, UE that doesn’t support dynamic switching between single-TRP and SFN scheme (scheme-1 or TRP-based pre-compensation) additional restriction on scheduling CORESET configuration is proposed to be activated only with single TCI state. Two companies (LGE [8], CMCC [11]) has also mentioned that for DCI Format 1\_0, scheduling CORESET should be also activated with two TCI states (as for DCI Formats 1\_1, 1\_2) if a UE supports this feature but is not capable of dynamic switching between single TRP and SFN. At the same time another company (ZTE [3]) has mentioned that in Rel-15/16, single TRP based PDSCH can be scheduled by DCI format 1\_0 since there is no DCI field. In Rel-17, DCI format 1\_0 should also be used to schedule single TRP based PDSCH no matter SFN PDSCH is configured or not, i.e. the function of DCI format 1\_0 should be the same for Rel-15/16/17. Hence if SFN PDSCH is configured and then it is scheduled by DCI format 1\_0, dynamic switching between single TRP and SFN should be supported. Based on above proposals the following alternatives were identified for further discussion regarding support of dynamic scheduling by DCI Format 1\_0.

**Issue #1-5:**

* **Alt 1**: If UE is configured with SFN scheme by RRC and not capable to support dynamic switching between 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 state
* **Alt 2**: If SFN PDSCH is configured by RRC, for PDSCH scheduled by DCI format 1\_0, dynamic switching between single TRP and SFN is supported

#### Round-1

**Proposal #1-5:**

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| **Company** | **Comment** |
| Moderator | The issue has been raised in the previous meetings, but no conclusion was reached. More inputs from other companies are needed.  |
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### Issue #1-6 (Default spatial / PL RS for Rel-17 multi-TRP PUSCH/PUCCH)

Two companies (ZTE [3], Samsung [13]) 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 for the corresponding cases.

**Issue #1-6:**

**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 mTRP 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:**

**Alt 1:** 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 mTRP 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.

**Alt 2**: UE does not expect that the network configures two SRS resource sets when default beam is enabled for PUSCH transmission scheduled by DCI format 0\_1 and 0\_2

**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

#### Round-1

**Proposal #1-6:**

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| **Company** | **Comment** |
| Moderator | The corresponding issues have been raised in the previous meeting, but no conclusion was made.  |
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### Issue #1-7 (BFR issues)

When SFN is configured for PDCCH, several enhancements for BFRQ were proposed in the previous meetings:

* UE capability for the larger number of BFD RS for the implicit BFD RS
* The rules for selecting multiple BFD RSs for implicit BFD RS configuration.
* Explicit BFD RS configuration
* NBI RS configuration
* Applicability of BFR enhancements

**Proposal 1:**

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

**Proposal 2:**

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, how to calculate radio link quality for RLM/BFD is up to RAN4 discussion per RAN1#107e agreement.
* **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(1), ZTE(2), Xiaomi (2), QC(2a), Mediatek (2), LGE (1 or 3), vivo (2), Huawei/HiSilicon (2), NEC (1),
	+ **Not supported**: Spreadtrum

**Proposal 3:**

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**: ZTE, CATT, Xiaomi, Lenovo / MotMob, Apple, DOCOMO, Xiaomi, Sony, NEC,

**Proposal 4:**

When two TCI states are activated for a CORESET, NBI RS can be also configured

* 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, CATT
* **Not supported**: vivo, Mediatek, Convida, OPPO, QC, LGE, vivo, Huawei / HiSilicon, Sony, Spreatrum,

**Proposal 5:**

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.

#### Round-1

**Proposal #1-7:**

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| **Company** | **Comment** |
| Moderator | Additional inputs from other companies are needed.  |
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### Issue #1-8 (RLM issues)

In RAN1#107e, whether/how to enhance RLM RS selection rule considering CORESET activated with two TCI states was proposed, however, due to lack of time was not discussed. Two companies (DOCOMO [6], Nokia/NSB [16]) have raised similar question in this meeting regarding selection priority of RLM RS and the following proposal was made.

**Issue #1-8:**

* For implicit configuration of failure detection RS for BFD and RLM, apply the same selection rule for RLM-RS and BFD-RS.

#### Round-1

**Proposal #1-8:**

* TBD

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| **Company** | **Comment** |
| Moderator | More inputs are required including more detailed proposal if any. The issue can be also discussed after BFR is finalized. |
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### Issue #1-9 (SFN for CORESETS associated with CSS Type 0/0A/1/2)

One company (Qualcomm [15]) has mentioned that PDCCH candidates in CSS type 0/0A/1/2 should not be associated with SFN CORESET, since CSS type 0/0A/1/2 are used for scheduling PDSCH carrying broadcast messages (SIB1, OSI, paging, MSG2/4 or paging). For TPR-based pre-compensation scheme, it is not expected that network can pre-compensate such PDCCH as different UEs may experience different Doppler frequency shifts. Other companies (OPPO [4], Lenovo/MotMob [14]) have mentioned that such association should be allowed, but for PDCCH reception only one TCI state should be used by the UE.

**Issue #1-9**:

* Alt 1: UE doesn’t expect PDCCH candidates in CSS type 0/0A/1/2 to be associated with CORESET activated with two TCI states.
* Alt 2: If PDCCH candidates in CSS 0/0A/1/2 are associated with CORESET that activated with two TCI states, the first TCI state is applied for the CSS reception

####  Round-1

**Proposal #1-9**:

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| **Company** | **Comment** |
| Moderator | This issue has been discussed in the previous meeting. Inputs from other companies are needed.  |
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### Issue #1-10 (PDSCH scheduled by CSS Type 0/0A/1/2)

One company (OPPO [4]) has mentioned that DCI format 1\_0 in CSS will follow the TCI state of the scheduling CORESET or the CORESET with lowest ID according to the scheduling offset. If the DCI is used to scheduling broadcast information, 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 reception.

**Issue #1-10**:

For PDSCH scheduled by CSS 0/0A/1/2

* 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 #1-10**:

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### Issue #1-11 (SRS configuration enhancement)

One company (Nokia/NSB [16]) has observed that single SRS transmission toward one TRP may degrade the frequency offset estimation in the other TRP. To support SRS-based frequency pre-compensation, the SRS transmission should have different RS for spatial relation and path loss calculation. In Rel-16, each SRS resource can be configured with its own spatial relation information. However, only one set of power control parameters (pathloss RS, alpha, P0) is configured for a SRS resource set.

**Issue #1-11:**

* For SRS based frequency offset estimation, UE should be configured with two SRS resources to different TRPs, where each SRS resource is configured with at least a different PL-RS.

#### Round-1

**Proposal #1-11:**

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| **Company** | **Comment** |
| Moderator | More inputs are needed. |
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### Issue #1-12 (LS reply on MAC CE application to CORESET 0)

In the LS on "Enhanced TCI state indication for UE specific PDCCH MAC CE” [R1-2200886], RAN2 has asked RAN1 whether MAC CE can be applied to any CORESET (including CORESET zero).

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| **Question: RAN2 would like to ask whether “Enhanced TCI state indication for UE specific PDCCH MAC CE” can be applied to CORESET zero or not.** |

**Issue #1-12:**

* **Alt 1:** Enhanced TCI state indication for UE specific PDCCH MAC CE can be applied to CORESET zero.

**Supported by**: Ericsson, vivo, ZTE, Intel, OPPO, Lenovo / MotMob, Apple, CMCC, Samsun, Nokia . ТЫИ, Huawei / HiSilicon

* **Alt 2:** The Enhanced TCI state indication for UE-specific PDCCH MAC CE can’t be applicable to CORESET zero.

**Supported by**: Qualcomm

Considering majority view the following proposal was made.

#### Round-1

**Proposal #1-12:**

* Enhanced TCI state indication for UE specific PDCCH MAC CE can be applied to any CORESET including CORESET zero.

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## Maintenance of the current specification version

This section contains issues related to the agreements made during work item phase that were not captured or captured with errors in the specification.

### Issue #2-1 (Configuration of the transmission schemes)

Several agreements were made in the previous meeting regarding restriction in configuration of SFN schemes for PDCCH, PDSCH and CA scenarios. However, the corresponding agreements were not correctly reflected in TS 38.214. Several companies have proposed TPs to correct these issues.

**TP#1 (Qualcomm [15])**

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| **38.214 CR – Clause 5.1**If a UE is configured with *sfnSchemePdcch* set to*'*sfnSchemeB*'* for a DL BWP or the UE does not report its capability of [*nonSfnPdsch-sfnPdcch*], the UE shall be configured with *sfnSchemePdsch* set to the same scheme as configured for *sfnSchemePdcch* |

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| TP – clause 5.1 When a UE is configured with both sfnSchemePdsch and sfnSchemePdcch, the UE shall expect that sfnSchemePdsch and sfnSchemePdcch are set to the same scheme, either 'sfnSchemeA' or 'sfnSchemeB' for all component carriers in the same band.  |

**TP#2 (vivo [2])**

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| **TS 38.214****5.1 UE procedure for receiving the physical downlink shared channel**< Unchanged parts are omitted >When a UE is configured with higher layer parameter *sfnSchemePdsch* set to either *'*sfnSchemeA*'* or *'*sfnSchemeB*'* for a DL BWP and - if the UE reports its capability of [*dynamicSFN*], the UE is indicated with one or two TCI state(s) in a codepoint of the DCI field *'Transmission Configuration Indication'* in DCI format 1\_1/1\_2, or- otherwise, the UE is not expected to be indicated with one TCI state per any of TCI codepoint by MAC CE, and the UE is indicated with two TCI states in a codepoint of the DCI field *'Transmission Configuration Indication'* in DCI format 1\_1/1\_2, andthe UE procedure for receiving the PDSCH upon detection of a PDCCH follows clause 5.1 and the QCL assumption for the PDSCH as defined in clause 5.1.5.When a UE is configured with both *sfnSchemePdsch* and *sfnSchemePdcch*, the UE shall expect that *sfnSchemePdsch* and *sfnSchemePdcch* are set to the same scheme, either *'*sfnSchemeA*'* or *'*sfnSchemeB*'*.If a UE is configured with sfnSchemePdcch set to 'sfnSchemeA' for a DL BWP and activated with two TCI states by MAC CE, and the UE does not report its capability of [nonSfnPdsch-sfnPdcch], the UE does not expect to be indicated with one TCI state in a codepoint of the DCI field 'Transmission Configuration Indication' in DCI format 1\_1/1\_2.If a UE is configured with sfnSchemePdcch set to 'sfnSchemeB' for a DL BWP and activated with two TCI states by MAC CE, the UE does not expect to be indicated with one TCI state in a codepoint of the DCI field 'Transmission Configuration Indication' in DCI format 1\_1/1\_2.When a UE is configured with *sfnSchemePdsch* and/or *sfnSchemePdcch* for a DL BWP, the UE shall expect that the *sfnSchemePdsch* and/or *sfnSchemePdcch* configuration are the same in the other DL BWP other than initial BWP [and BWP-DownlinkCommon]. < Unchanged parts are omitted > |

**TP#3 (Spreadtrum [7])**

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| **TS 38.214**-----------------------------Unchanged part omitted--------------------------When a UE is configured with both *sfnSchemePdsch* and *sfnSchemePdcch*, the UE shall expect that *sfnSchemePdsch* and *sfnSchemePdcch* are set to the same scheme, either *'*sfnSchemeA*'* or *'*sfnSchemeB*'*.If a UE reports its capability of [TBD], the UE can be configured with *sfnSchemePdcch set* to *'*sfnSchemeA*'* when not configured with *sfnSchemePdsch*.------------------------------------------End of Text Proposal#1 for TS 38.214------------------------------------ |

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| **TS 38.214**-----------------------------Unchanged part omitted--------------------------When a UE is configured with *sfnSchemePdsch* and/or *sfnSchemePdcch* for a DL BWP, the UE shall expect that the *sfnSchemePdsch* and/or *sfnSchemePdcch* configuration are the same in the other DL BWP other than initial BWP [and BWP-DownlinkCommon] across all CCs in a band. ------------------------------------------End of Text Proposal#2 for TS 38.214------------------------------------ |

**TP#4 (Xiaomi [12])**

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| **-------------------------- Start of Text Proposal for TS 38.214 --------------------------****<Unchanged parts omitted>**5.1 UE procedure for receiving the physical downlink shared channel…When a UE is configured with both *sfnSchemePdsch* and *sfnSchemePdcch*, the UE shall expect that *sfnSchemePdsch* and *sfnSchemePdcch* are set to the same scheme, either *'*sfnSchemeA*'* or *'*sfnSchemeB*'*.When a UE is configured with *sfnSchemePdsch* and/or *sfnSchemePdcch* for a ~~DL BWP~~ CC, the UE shall expect that the *sfnSchemePdsch* and/or *sfnSchemePdcch* configuration are the same in the other ~~DL BWP other than initial BWP [and BWP-DownlinkCommon]~~ CC in a same frequency band if the UE is configured with CA.…**<Unchanged parts omitted>****-------------------------- End of Text Proposal for TS 38.214 --------------------------** |

#### Round-1

**TP#2-1 (Consolidated)**

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| **TS 38.214****<Unchanged parts are omitted>**5.1 UE procedure for receiving the physical downlink shared channel…When a UE is configured with higher layer parameter *sfnSchemePdsch* set to either *'*sfnSchemeA*'* or *'*sfnSchemeB*'* for a DL BWP and - if the UE reports its capability of [*dynamicSFN*], the UE is indicated with one or two TCI state(s) in a codepoint of the DCI field *'Transmission Configuration Indication'* in DCI format 1\_1/1\_2, or- otherwise, the UE is not expected to be indicated with one TCI state per any of TCI codepoint by MAC CE, and the UE is indicated with two TCI states in a codepoint of the DCI field *'Transmission Configuration Indication'* in DCI format 1\_1/1\_2, andthe UE procedure for receiving the PDSCH upon detection of a PDCCH follows clause 5.1 and the QCL assumption for the PDSCH as defined in clause 5.1.5.When a UE is configured with both *sfnSchemePdsch* and *sfnSchemePdcch*, the UE shall expect that *sfnSchemePdsch* and *sfnSchemePdcch* are set to the same scheme, either *'*sfnSchemeA*'* or *'*sfnSchemeB*'*.If a UE is configured with sfnSchemePdcch set to 'sfnSchemeA' for a DL BWP and activated with two TCI states by MAC CE, and the UE does not report its capability of [nonSfnPdsch-sfnPdcch], the UE does not expect to be indicated with one TCI state in a codepoint of the DCI field 'Transmission Configuration Indication' in DCI format 1\_1/1\_2.If a UE is configured with sfnSchemePdcch set to 'sfnSchemeB' for a DL BWP and activated with two TCI states by MAC CE, the UE does not expect to be indicated with one TCI state in a codepoint of the DCI field 'Transmission Configuration Indication' in DCI format 1\_1/1\_2.When a UE is configured with *sfnSchemePdsch* and/or *sfnSchemePdcch* for a ~~DL BWP~~ CC, the UE shall expect that the *sfnSchemePdsch* and/or *sfnSchemePdcch* configuration are the same in the other ~~DL BWP other than initial BWP [and BWP-DownlinkCommon]~~ CC in a same frequency band if the UE is configured with CA.…**< Unchanged parts are omitted >** |

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### Issue #2-2 (QCL for aperiodic CSI-RS reception with SFN Scheme B)

One company (Huawei / HiSilicon [1]) has mentioned that default beam for aperiodic CSI-RS reception has been agreed to support scheme 1 or TRP-based pre-compensation. However, the default beam for aperiodic CSI-RS reception with TRP-based pre-compensation was not captured in the spec.

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| **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 |

#### Round-1

**TP#2-2**

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| **TS 38.214** < Unchanged parts are omitted > - else if a UE is configured with *sfnSchemePdcch* set to *'*sfnSchemeA' or *'*sfnSchemeB', it is not configured with *enableTwoDefaultTCI-States,* and the two TCI states are activated for the CORESET by the activation command as described in clause 6.1.3.x of [10, TS 38.321]- if there is any other DL signal with an indicated TCI state in the same symbols as the CSI-RS, the UE applies the QCL assumption of the other DL signal also when receiving the aperiodic CSI-RS. The other DL signal refers to PDSCH scheduled with an offset larger than or equal to the threshold *timeDurationForQCL,* as defined in [13, TS 38.306], periodic CSI-RS, semi-persistent CSI-RS, aperiodic CSI-RS in a *NZP-CSI-RS-ResourceSet* scheduled with offset larger than or equal to the UE reported threshold *beamSwitchTiming* when the reported value is one of the values {14,28,48} and when *enableBeamSwitchTiming* is not provided or the *NZP-CSI-RS-ResourceSet* is configured with the higher layer parameter *trs-Info* , aperiodic CSI-RS in a *NZP-CSI-RS-ResourceSet* configuredwith the higher layer parameter *repetition* set to 'off' or configured without the higher layer parameters *repetition* and *trs-Info* scheduled with offset larger than or equal to 48 when the UE provides *beamSwitchTiming-r16* and *enableBeamSwitchTiming* is provided, aperiodic CSI-RS in a *NZP-CSI-RS-ResourceSet* configuredwith the higher layer parameter *repetition* set to 'on' scheduled with offset larger than or equal to the UE reported threshold *beamSwitchTiming-r16* and *enableBeamSwitchTiming* is provided;- else if, the UE applies the first one of two TCI states indicated for the CORESET with the lowest CORESET ID in the latest slot within the active BWP of the cell in which the CSI-RS is to be received when receiving the aperiodic CSI-RS, < Unchanged parts are omitted >< End of text proposal 38.214 v17.0.0 Section 5.2> |

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### Issue #2-3 (DCI Formats 0\_0, 1\_1, or 1\_2, for SFN PDSCH)

One company (NTT DOCOMO [6]) has mention that if *enableTwoDefaultTCI-States* is configured, the two default TCI states are derived from active TCI states for PDSCH, similar to Rel-16 single DCI based M-TRP operation. However, Rel-17 SFN the specification should be applied to PDSCH scheduled by DCI format 1\_0/1\_1/1\_2, while for single DCI based M-TRP in Rel.16, to PDSCH scheduled by DCI format 1\_1/1\_2 only.

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| **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 |

Therefore, it is proposed to clarify that the specification is applied to PDSCH scheduled by DCI format 1\_0.

#### Round-1

**TP#2-3**

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| **TS 38.214**5.1.5 Antenna ports quasi co-location[…]Independent of the configuration of *tci-PresentInDCI* and *tci-PresentDCI-1-2* in RRC connected mode, if the offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL* and at least one configured TCI state for the serving cell of scheduled PDSCH contains *qcl-Type* set to 'typeD', […]- If a UE is configured with *enableTwoDefaultTCI-States*, and at least one TCI codepoint indicates two TCI states, the UE may assume that the DM-RS ports of PDSCH or PDSCH transmission occasions of a serving cell are quasi co-located with the RS(s) with respect to the QCL parameter(s) associated with the TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states. This is applied to PDSCH scheduled by DCI format 1\_0, 1\_1, or 1\_2, if UE is configured with *sfnSchemePdsch*. When the UE is configured by higher layer parameter *repetitionScheme* set to 'tdmSchemeA' or is configured with higher layer parameter *repetitionNumber*, and the offset between the reception of the DL DCI and the first PDSCH transmission occasion is less than the threshold *timeDurationForQCL,* the mapping of the TCI states to PDSCH transmission occasions is determined according to clause 5.1.2.1 by replacing the indicated TCI states with the TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states based on the activated TCI states in the slot with the first PDSCH transmission occasion. In this case, if the 'QCL-TypeD' in both of the TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states is different from that of the PDCCH DM-RS with which they overlap in at least one symbol, the UE is expected to prioritize the reception of PDCCH associated with that CORESET. This also applies to the intra-band CA case (when PDSCH and the CORESET are in different component carriers) |

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### Issue #2-4 (QCL assumptions for CSI-RS)

One company (vivo [2]) mentioned that RAN1 has made agreement below on TCI state for CSI-RS reception 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” in the agreement is not appropriate considering the description in the current spec TS 38.214, because this is not a default beam issue, but an issue to guarantee the same beam for CSI-RS and PDCCH.

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| **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. |

In order to avoid the confusion, TP was proposed to reflect the real meaning more clearly and keep the similar description as what in Rel-16 spec 38.214.

#### Round-1

**TP#2-4**

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| **TS 38.214****5.1.6.1 CSI-RS reception procedure**< Unchanged parts are omitted >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 activated with one TCI state 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. If the CORESET is activated with two TCI states, UE may assume that quasi co-location with ‘typeD’ in the first TCI state of the CORESET is the same as the ~~default~~ quasi co-location with ‘typeD’ ~~QCL assumption~~ for the CSI-RS, 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).< Unchanged parts are omitted > |

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### Issue #2-5 (Default beam for PUCCH)

One company (ZTE [3]) has mentioned that the default spatial relation and PL-RS of single-TRP PUCCH/PUSCH/SRS transmission has been agreed in RAN1#106 e-meeting for the case when SFN PDCCH transmission is configured, but in current specification, the related agreements were not captured. Hence, the following text proposal was made.

#### Round-1

**TP#2-5**

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| **38.213: 9.2.2 PUCCH Formats for UCI transmission**<Unchanged part omitted>If a UE- is not provided *pathlossReferenceRSs* in *PUCCH-PowerControl*, - is provided *enableDefaultBeamPL-ForPUCCH*, and - is not provided *PUCCH-SpatialRelationInfo*, and- is not provided coresetPoolIndex value of 1 for any CORESET, or is provided coresetPoolIndex value of 1 for all CORESETs, in ControlResourceSet and no codepoint of a TCI field, if any, in a DCI format of any search space set maps to two TCI states [5, TS 38.212]a spatial setting for a PUCCH transmission from the UE is same as a spatial setting for PDCCH receptions by the UE in the CORESET with the lowest ID on the active DL BWP of the PCell, if the CORESET has two activated TCI states, as described in clause 10.1, the UE determines the spatial setting based on the first TCI state. For a PUCCH transmission over multiple slots, a same spatial setting applies to the PUCCH transmission in each of the multiple slots.<Unchanged part omitted> |

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### Issue #2-6 (UE capability for default beam for PUCCH)

One company (Spreadtrum [7]) has mentioned that there was agreement to support default beam and PL RS determination for PUCCH and SRS based on the first TCI state of the CORESET, up to UE capability. In RAN1#107b-e meeting, during UE feature discussion, RAN1 has already agreed to introduce UE FG ‘Default UL beam setup for SFN’ to reflect the feature. However, the corresponding agreement was not reflected in the specification.

#### Round-1

**TP#2-6**

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| **TS 38.213**-----------------------------Unchanged part omitted--------------------------- If the UE- is not provided *pathlossReferenceRSs*, and- is not provided *PUCCH-SpatialRelationInfo,* and- is provided *enableDefaultBeamPL-ForPUCCH*, and - is not provided coresetPoolIndex value of 1 for any CORESET, or is provided coresetPoolIndex value of 1 for all CORESETs, in ControlResourceSet and no codepoint of a TCI field, if any, in a DCI format of any search space set maps to two TCI states [5, TS 38.212]  the UE determines a RS resource index $q\_{d}$ providing a periodic RS resource configured with *qcl-Type* set to 'typeD' in the TCI state or the QCL assumption of a CORESET with the lowest index in the active DL BWP of the primary cell. If the CORESET has two activated TCI states, as described in clause 10.1, and the UE reports [Default UL beam setup for SFN], the UE determines the RS resource index $q\_{d}$ based on the first activated TCI state. For a PUCCH transmission over multiple slots, a same $q\_{d}$ applies to the PUCCH transmission in each of the multiple slots.-----------------------------Unchanged part omitted-------------------------------------------------------Unchanged part omitted-------------------------- the UE determines a RS resource index $q\_{d}$ providing a periodic RS resource configured with *qcl-Type* set to 'typeD' in- the TCI state or the QCL assumption of a CORESET with the lowest index in the active DL BWP, if CORESETs are provided in the active DL BWP of serving cell $c$. If the CORESET has two activated TCI states, as described in clause 10.1, and the UE reports [Default UL beam setup for SFN], the UE determines the RS resource index $q\_{d}$ based on the first TCI state.- the active PDSCH TCI state with lowest ID [6, TS 38.214] in the active DL BWP, if CORESETs are not provided in the active DL BWP of serving cell $c$------------------------------------------End of Text Proposal#3 for TS 38.213-------------------------------------- |

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### Issue #2-7 (FFS on BWP-DownlinkCommon)

Two companies (CMCC [11], Xiaomi [12]) have mentioned that BWP-DownlinkCommon is not actual BWP and should removed from the agreement and specification. At the same time one company (Ericsson [9]) has mentioned that the content of BWP-DownlinkCommon, includes cell specific configurations, and “per BWP” configuration it can only make sense that the BWP is BWP-DownlinkDedicated and it is proposed to remove “FFS:” from the agreement. Considering slight majority for the first option to implement common understanding, the following TP is proposed.

#### Round-1

**TP#2-7**

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| **TS 38.214**----------------- Start of TP ----------------5.1 UE procedure for receiving the physical downlink shared channel**<**Unchanged text is omitted>When a UE is configured with *sfnSchemePdsch* and/or *sfnSchemePdcch* for a DL BWP, the UE shall expect that the *sfnSchemePdsch* and/or *sfnSchemePdcch* configuration are the same in the other DL BWP other than initial BWP ~~[and BWP-DownlinkCommon]~~. **<**Unchanged text is omitted>----------------- End of TP ---------------- |

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# References

[1] R1-2200933, Remaining issues on HST multi-TRP deployment in Rel-17, Huawei, HiSilicon

[2] R1-2201082, Maintenance on HST-SFN schemes, vivo

[3] R1-2201189, Remaining issues on multi-TRP HST enhancements, ZTE

[4] R1-2201227, Enhancements on HST-SFN deployment, OPPO

[5] R1-2201332, Discussion on remaining issues on Rel-17 HST-SFN, CATT

[6] R1-2201467, Remaining issues on HST-SFN deployment, NTT DOCOMO, INC.

[7] R1-2201538, Discussion on enhancements on HST-SFN deployment, Spreadtrum Communications

[8] R1-2201571, Enhancements on HST-SFN deployment, LG Electronics

[9] R1-2201618, Finalizing Multi-TRP HST-SFN enhancements, Ericsson

[10] R1-2201686, Maintenance of HST-SFN enhancements, Intel Corporation

[11] R1-2201848, Remaining issues of enhancements on HST-SFN deployment, CMCC

[12] R1-2201945, Remaining issues on HST-SFN deployment enhancement, Xiaomi

[13] R1-2202000, Maintenance on Rel-17 HST-SFN, Samsung

[14] R1-2202088, Enhancements for HST-SFN deployment, Lenovo

[15] R1-2202126, Enhancements on HST-SFN deployment, Qualcomm Incorporated

[16] R1-2202494 (R1-2202320), Maintenance of enhancements for HST-SFN deployment, Nokia, Nokia Shanghai Bell

# 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**

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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.
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## **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
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## **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
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## **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
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## **RAN1#107-e meeting**

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| **Agreement**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.**Agreement**For intra-band CA, UE doesn’t expect configurations of different SFN schemes in different CCs**Agreement**TRP-based pre-compensation scheme for PDSCH / PDCCH is supported in both FR1 and FR2 with UE capability at least per FR* Note: While majority of the companies support above, only one company has shown benefit on TRP-based pre-compensation scheme for PDSCH in FR2 with 200m ISD. Evaluation methodology and results can be found in R1-2101450.

**Agreement**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* 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, the second QCL-typeD is not identified

**Agreement**When SFN PDSCH is not configured by RRC and there is no TCI codepoint which indicates two TCI states activated for the PDSCH (i.e. Rel-16 MTRP PDSCH is not configured) and SFN transmission scheme 1 is configured for PDCCH, for PDSCH reception scheduled by DCI format 1\_0, 1\_1, 1\_2 without TCI field, if the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold t*imeDurationForQCL* if applicable and 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**Agreement**The agreement from RAN1#106b-e meeting is updated as followsWhen SFN PDSCH is not configured by RRC and there is no TCI codepoint which indicates two TCI states activated for the PDSCH (i.e. Rel-16 MTRP PDSCH is not configured), 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
* It is up to editor how to capture the above agreement

**Agreement**If PDCCH candidates in CSS 3 are associated with CORESET that is activated with two TCI states and configured with enhanced SFN scheme 1 or TRP based pre-compensation, both TCI states can be applied for the CSS reception. * FFS: Whether/How specification change is needed is up to the editor

**Agreement**For a CORESET with two activated TCI states, for implicit BFD RS, how to calculate radio link quality for RLM /BFD is up to RAN4 discussion* Send LS to let RAN4 to let them know about two possible options of radio link quality estimation for RLM /BFD using each RS or RS pair of CORESET activated with two TCI states. RAN1 has discussed both options, but was not able to reach a consensus. Inform that it is up to RAN4 to specify the most appropriate option. LS is endorsed in R1-2112829.

**Agreement**When SFN PDSCH and SFN PDCCH are configured by RRC , for PDSCH reception scheduled by DCI formats 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
	+ 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 both QCL assumptions of the CORESET that schedules the PDSCH when receiving the PDSCH
		- otherwise, if there is one active TCI state for the CORESET , UE applies the one active TCI state of the CORESET when receiving the PDSCH

This feature is UE optional capability* If UE doesn’t support this capability, UE is expected to be configured with TCI state field
* UEs supporting this feature and are not capable of dynamic switching between single TRP and SFN , the CORESET that schedules PDSCH by DCI formats 1\_1 and 1\_2 (FFS DCI format 1\_0) should be activated with two TCI states.

FFS for maintenance: if SFN PDCCH is not configured |