**3GPP TSG RAN WG1 #106-e R1-210xxxxx**

**e-Meeting, August 16th – 27th, 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 company’s and moderator’s proposals.

# Possible enhancements for HST-SFN deployment

The section summarizes company proposals regarding enhancements that can be supported for HST-SFN deployment. The proposals are based on the contributions [2]-[24] submitted to RAN1#106-e meeting.

## General issues

### Issue #1-1 (Combination of the 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. In RAN1#105e meeting it was agreed to support the same configuration of the transmission schemes on PDCCH and PDSCH. However, it should be further discussed whether to support other transmission schemes in combination of enhanced SFN transmission scheme for PDSCH or PDCCH.

#### Round-1

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|  |  | PDSCH | | | |
| PDCCH |  | Rel-15 | Rel-16 | Scheme 1 | Pre-compensation |
| Rel-15 | N/A | N/A | ? | ? |
| Rel-17 URLLC | N/A | N/A | ? | ? |
| Scheme 1 | ? | ? | Supported | Not supported |
| Pre-compensation | ? | ? | Not supported | Supported |

Companies are invited to provide their views regarding additional combinations of the transmission schemes should be additionally supported.

**Proposal #1-1:**

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| **Company** | **Comment** |
| ZTE | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | PDSCH | | | | | PDCCH |  | Rel-15 | Rel-16 | Scheme 1 | Pre-compensation | | Rel-15 | N/A | N/A | support | support | | Rel-17 URLLC | N/A | N/A | ? | ? | | Scheme 1 | support | support | Supported | No supported | | Pre-compensation | support | support | Not supported | Supported | |
| Apple | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | PDSCH | | | | | PDCCH |  | Rel-15 | Rel-16 | Scheme 1 | Pre-compensation | | Rel-15 | N/A | N/A | Not support  Or FFS on the limitation of SearchSpace etc | Not support  Or FFS on the limitation of SearchSpace etc | | Rel-17 URLLC | N/A | N/A | FFS | FFS | | Scheme 1 | Not support | Not support | Supported | No supported | | Pre-compensation | Not support | Not support | Not supported | We first need agreement to support pre-compensation for PDCCH | |
| Sony | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | PDSCH | | | | | PDCCH |  | Rel-15 | Rel-16 | Scheme 1 | Pre-compensation | | Rel-15 | N/A | N/A | Not support | Not support | | Rel-17 URLLC | N/A | N/A | ? | ? | | Scheme 1 | Not support | Not support | Supported | No supported | | Pre-compensation | Not support | Not support | Not supported | Support | |
| DOCOMO | Agree with ZTE. We think it is safer approach to allow Rel.15 PDCCH can schedule HST-SFN schemes. If not, SFN-PDCCH will be mandatory/basic feature for HST-SFN schemes for PDSCH.  Please note that in RAN4, both Rel.14 LTE HST and Rel.16 NR HST only specified demodulation requirement for PDSCH. We cannot predict RAN4 will specify demodulation requirement for both PDSCH/PDCCH in Rel.17 RAN4. |
| OPPO | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | PDSCH | | | | | PDCCH |  | Rel-15 | Rel-16 | Scheme 1 | Pre-compensation | | Rel-15 | N/A | N/A | Not support | Not support | | Rel-17 URLLC | N/A | N/A | ? | ? | | Scheme 1 | Not support | Not support | Supported | No supported | | Pre-compensation | Not support | Not support | Not supported | Supported |   If RAN1 supports the highlighted cases, there can be many cases with different transmission schemes assumption (S-TRP and SFN) for default TCI state (usually comes from CORESET) and DCI indicated TCI state (for PDSCH), which requires UE to support dynamic switching between S-TRP and SFN transmission. |
| vivo | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | PDSCH | | | | | PDCCH |  | Rel-15 | Rel-16 | Scheme 1 | Pre-compensation | | Rel-15 | N/A | N/A | Support | Support | | Rel-17 URLLC | N/A | N/A | Not support | Not support | | Scheme 1 | Support | Not support | Supported | Not supported | | Pre-compensation | Support | Not support | Not supported | Support |   For R16 S-DCI based MTRP schemes, STRP-based PDCCH can be used to schedule MTRP-based PDSCH. Naturally, scheme 1 and pre-compensation scheduled by STRP-based PDCCH should also be supported. Besides, scheme 1 /Pre-compensation based PDCCH can increase the reliability for PDCCH transmission, so scheme 1/Pre-compensation based PDCCH scheduling STRP-based PDSCH can also be supported. |
| Lenovo/MotM | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | PDSCH | | | | | PDCCH |  | Rel-15 | Rel-16 | Scheme 1 | Pre-compensation | | Rel-15 | N/A | N/A | Not support | Not support | | Rel-17 URLLC | N/A | N/A | Not support | Not support | | Scheme 1 | Not support | Not support | Supported | No supported | | Pre-compensation | Not support | Not support | Not supported | Support |   In our opinion, PDSCH and PDCCH transmissions should follow the same HST-SFN scheme |
| MediaTek | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | PDSCH | | | | | PDCCH |  | Rel-15 | Rel-16 | Scheme 1 | Pre-compensation | | Rel-15 | N/A | N/A | Not support | Not support | | Rel-17 URLLC | N/A | N/A | Not support | Not support | | Scheme 1 | Not support | Not support | Supported | No supported | | Pre-compensation | Not support | Not support | Not supported | Support | |
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### Issue #1-2 (TRP-based pre-compensation in FR2)

One company has mentioned inconsistency in the agreement on support of TRP-based pre-compensation scheme in FR1 only and agreement on default beams relying on QCL-typeD (implying support of FR2). To simplify discussion in RAN1, it is proposed to clarify whether support of TRP-based pre-compensation is limited to FR1 only (i.e., the previous agreement of default beam should be revised to exclude TRP-based pre-compensation) or support of TRP-based pre-compensation is extended to FR2.

**Issue#1-2:**

* Whether TRP-based pre-compensation scheme for PDSCH / PDCCH is supported in FR1 only or in FR1+FR2

Companies are invited to provide their views on this issue.

#### Round-1

**Proposal #1-2:**

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| **Company** | **Comment** |
| ZTE | In both FR1 and FR2 |
| Apple | At least we need separate capability for FR1 and FR2 since FR2 requires multi panel simultaneous reception. Also it is a general question even for HST-SFN scheme 1. |
| Sony | Support both FR1 and FR2 and fine with separate UE capabilities in FR1 and FR2. |
| DOCOMO | We assume in both FR1 and FR2.  We think it is reasonable to have the separate UE capability for FR1 and FR2, but it can be discussed in UE feature discussion. |
| OPPO | Support separate UE capability for FR1 and FR2. |
| vivo | Support both FR1 and FR2 |
| Lenovo/MotM | Both FR1 and FR2. OK to discuss further under UE capability |
| MediaTek | Both FR1 and FR2 |
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### Issue #1-3 (Configuration of enhanced SFN for PDCCH)

Regarding configuration of the enhanced SFN transmission scheme to PDCCH. In RAN1#104b-e meeting it was agreed that MAC CE can activate two TCI states per CORESET resulting in possibly different transmission schemes for different CORESETs. However, some companies indicated a preference to have common activation/configuration of the transmission schemes for all CORESETs. Based on this proposal companies are invited to share their views on this proposal.

**Issue#1-3:**

* Enhanced SFN (scheme 1 or TRP-based pre-compensation) if configured is activated for all CORESETs
  + FFS CORESET#0

Companies are invited to provide their views on this issue.

#### Round-1

**Proposal #1-3:**

* TBD

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| **Company** | **Comment** |
| ZTE | No. One or two TCI can be activated by MACCE for different CORESETs. |
| Apple | We are fine with the FL proposal |
| Sony | In previous meeting, dynamic switching (based on UE capability) between S-TRP PDSCH (fallback scheme) and SFN PDSCH was supported, and PDCCH and PDSCH should be applied with the SFN scheme or non-SFN scheme. Hence, we think it’s too restrictive to active the same number (2) of TCI states for all CORESETs. |
| DOCOMO | Not support. Same view with ZTE. |
| OPPO | Support. Without the restriction, there can be many cases with different transmission schemes assumption (S-TRP and SFN) for default TCI state (comes from lowest ID CORESET) and non-default TCI state (comes from scheduling CORESET) for PDSCH without TCI field, which requires UE to support dynamic switching between S-TRP and SFN transmission. |
| vivo | The common RRC parameter should be configured for all CORESETs, then the number of TCI states in MAC CE can further determine whether the CORESET is STRP-based or SFN-based. |
| Lenovo/MotM | We think it is too strict and prefer flexible activation of one or two TCI state per CORESET to support flexible single TRP or multiple TRP PDCCH transmission |
| MediaTek | Support the proposal. |
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### Issue #1-4 (Common RRC parameter for PDCCH and PDSCH)

In case additional combinations of the transmission schemes are not supported (see Issue#1-1), common or separate RRC parameter for configuration of enhanced SFN transmission scheme for PDCCH and PDSCH should be decided.

**Issue#1-4:**

* Support separate RRC parameter for PDCCH and PDSCH for enhanced SFN configuration (scheme 1 or TRP-based pre-compensation scheme)
  + **Supported**: CATT, Intel, Ericsson, Apple (combination of SFN and other transmission scheme is optional feature), Nokia/NSB, DOCOMO
* Support common RRC parameter for PDCCH and PDSCH for enhanced SFN configuration (scheme 1 or TRP-based pre-compensation scheme)
  + **Supported**: Lenovo/MotMobility, OPPO, Qualcomm, Sony, vivo, MediaTek

Companies are invited to provide their views on this issue.

#### Round-1

**Proposal #1-4:**

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| **Company** | **Comment** |
| Moderator | The granularity of RRC configuration can be decided in RRC discussion sessions for Rel-17 |
| Apple | We prefer the second bullet (common RRC parameter)  For the first bullet, we need to further discuss that it is optional feature (so the second bullet can always be the implantation choice for the UE), and the restriction on PDCCH schemes |
| Sony | Since RAN1 agreed the same SFN scheme (either scheme 1 or TRP-specific pre-compensation) for PDCCH and PDSCH, we think common RRC parameter would be fine for DL channels. |
| DOCOMO | We prefer the separate RRC parameter, but we think this should be discussed after Proposal #1-1. |
| OPPO | Support the same RRC parameter. Otherwise, the default TCI state of PDSCH would be complicated. |
| vivo | Support the common RRC parameter for SFN PDCCH and PDSCH. Using different MTRP schemes separately for PDCCH and PDSCH would require the UE to prepare two TRS/DMRS estimation processes, lead to more UE complexity. |
| Lenovo/MotM | We believe this should be discussed after reaching a conclusion on Issue #1-1. Based on our preference in Issue #1-1, our preference is supporting a common RRC parameter for PDSCH and PDCCH (second bullet) |
| MediaTek | Support the common RRC parameter |
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### Other issues

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

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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, …

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 a low priority issue |
| InterDigital | Supported |
| Apple | Support FL proposal |
| Sony | Support the FL proposal |
| DOCOMO | Fine with the proposal. |
| OPPO | Support the proposal |
| Lenovo/MotM | Support |
| MediaTek | Support |
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### Issue #2-2 (Support of scheme 2)

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

**Issue#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, …

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

#### Round-1

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

* Scheme 2 is not supported in Rel-17

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| **Company** | **Comment** |
| Moderator | This is a low priority issue |
| Apple | Support FL proposal |
| Sony | Support the FL proposal. |
| DOCOMO | Support |
| OPPO | Support. |
| vivo | Support |
| MediaTek | Support |
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### Other issues

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

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## TRP-based solutions

### Issue #3-1 (QCL types/assumptions when TRS/CSI-RS is source)

Regarding new QCL types/assumption for TRS/CSI-RS, when TRS/CSI-RS resource(s) is used as source RS in the TCI state.

**Issue#3-1:** Whether to confirm working assumption on support of Variant A for TRP-based pre-compensation as QCL types/assumption, when the same DMRS port(s) are associated with two TCI states

* Confirm working assumption without modification
  + **Supported**: Huawei / HiSilicon, CATT, Lenovo/Motorola Mobility, CMCC, MediaTek, Ericsson, LGE, Nokia/NSB, Spreadtrum, OPPO, Futurewei, ZTE, Samsung,
* Confirm working assumption with modification to also include Variant B
  + **Supported**: ZTE, Qualcomm, Intel, Ericsson (Variant A shall be supported), CATT, …

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

#### Round-1

**Proposal #3-1:** Confirm working assumption from RAN1#105e meeting without modification:

* 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

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| **Company** | **Comment** |
| ZTE | We are OK to confirm the working assumption first. But we still think additional support of Variant B is needed. |
| Apple | We are fine with FL proposal |
| DOCOMO | Fine to confirm the WA. |
| OPPO | Support the proposal. |
| vivo | Variant C can help network to process timing pre-compensation which is similar to frequency pre-compensation, and it can further improve the UE demodulation performance of SFN transmission as shown in our tdoc. We prefer to further discuss Variant C   * FFS: Additional support of Variant B and Variant C |
| Lenovo/MotM | Support |
| MediaTek | Support |
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### Issue #3-2 (TCI state for QCL parameters dropping)

Regarding rule or signalling to determine which TCI state contains dropped QCL parameters. The following approaches were identified by companies for TRP-based pre-compensation scheme as captured in Alt 1 and Alt 2.

**Issue#3-2:** For TRP-based pre-compensation

* **Alt-1**: QCL parameters are dropped from the second TCI state of TCI codepoint
  + **Supported**: vivo, CATT, Qualcomm, CMCC, Ericsson, LGE, Nokia/NSB, Sony, MediaTek, Huawei / HiSilicon,
* **Alt-2**: QCL parameters are dropped from TCI state indicated using signalling
  + FFS other details
  + **Supported**: ZTE (CDM group), Lenovo/MotMobility (Spatial relation info), Spreadtrum, Intel (nSCID), OPPO, Docomo, CATT, NEC, Samsung, Apple, , ,…

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

#### Round-1

**Proposal #3-2:** For TRP-based pre-compensation

* **Alt-1**: QCL parameters are dropped from the second TCI state of TCI codepoint containing two TCI states

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| **Company** | **Comment** |
| ZTE | We are OK to go for Alt-1 for progress |
| Apple | Not sure about the difference between Alt-1 and Alt-2. We think NW needs to explicitly informs the UE that some QCL parameters are dropped, otherwise, how do we differentiate scheme 1 and pre-compensation |
| Sony | We are fine with Alt-1 which seems like a pre-defined rule of QCL parameter(s) dropping. Without any dynamic signaling, we hope RAN1 can also specify a rule on which QCL parameter(s) is(are) dropped from the 2nd indicated TCI state. |
| DOCOMO | Support Alt.1. Re Apple’s question, our understanding is that different RRC parameter will be defined for scheme 1 and pre-compensation. |
| OPPO | Support the proposal. |
| vivo | Support the proposal. |
| Lenovo/MotM | Prefer Alt2. In our understanding, the order of TCI states, i.e., the TCI state corresponding to QCL parameters dropping, would change based on the train trajectory. Indicating the TCI state corresponding to dropping/not dropping QCL parameters (without the need to introduce new parameters) can help simplify the design |
| MediaTek | Support Alt-1 |
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### Issue #3-3 (Doppler frequency reporting)

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

**Issue#3-3:** Indication of carrier frequency for uplink transmission (Doppler frequency reporting) in TRP-based pre-compensation schemes

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

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

#### Round-1

**Proposal #3-3:** 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 to improve the accuracy of frequency estimation

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| **Company** | **Comment** |
| ZTE | We are OK to go for Option 1 now. But it is better to further discuss whether explicitly report is supported or not. In our view, it can be optionally supported for some scenarios e.g. FDD, or some bands without UL carrier. |
| InterDigital | Support FL proposal |
| Apple | If option 2, it needs to be UE optional feature for UE that support pre-compensation |
| Sony | We are okay with the implicit approach which involves less standard impact when compared with the explicit Doppler frequency reporting, but in previous agreement it said 1 or 2 approach(es) can be supported. In addition, we share similar view with ZTE on scenarios (FDD operation and TDD operation without UL carrier configured) where it seems explicit Doppler frequency reporting fits better.  So we hope we could support both Option 1 and Option 2. |
| DOCOMO | Not support. In FDD band, which is our main target of HST-SFN, Doppler would be different for UL and DL.  Based on the evaluation result (R1-2107625, Ericsson), Option 1 has performance degradation compared to Option 2. Hence, we should support the Option 2, even if it is optional feature. |
| OPPO | Support the proposal. If the frequency of UL and DL is known by gNB, Doppler estimated from UL can also be applied to DL via some calculation. |
| vivo | Support the proposal in principle. But if Doppler frequency is reported using the CSI framework, further enhancement on CSI(PMI/RI/CQI) for SFN transmission based on distributed CSI-RS can be also considered to further improve the SFN transmission performance. |
| Lenovo/MotM | Support the proposal. In our contribution (R1-2107178) we have provided analysis showing a variant of the pre-compensation scheme that takes into account the Duplexing distance between UL and DL carrier frequencies when estimating the frequency pre-compensation |
| MediaTek | Support the proposal |

### Issue #3-4 (QCL-like association between DL and UL RS)

Regarding support of QCL-like association between DL and UL RS, e.g., for carrier frequency indication in UL. Several companies provided their views whether carrier frequency requires specification support for indication or can be selected by the UE based on implementation. Company’s preferences on this issue are summarized below:

**Issue#3-4:** Whether to support QCL-like association between DL and UL RS?

* **Option 1**: QCL-like association of the resource(s) received in the 1st step with UL signal transmitted in the 2nd step is supported by specification. FFS between the following alternatives:
  + **Alt-1**: Explicit indication of the DL RS for QCL-like association
  + **Alt-2**: Implicit indication of DL RS for QCL-like association
* **Option 2**: QCL-like association of the resource(s) received in the 1st step with UL signal transmitted in the 2nd step is supported by implementation without specification impact

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

#### Round-1

**Proposal #3-4 (for 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
    - **Supported**: ZTE, vivo, Sony, Samsung, CATT, CMCC, Mediatek, Ericsson, Intel, LGE, Nokia/NSB
    - **Concerns**: Qualcomm?,

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| **Company** | **Comment** |
| Moderator | The conclusion may be needed to complete WID objective |
| ZTE | Support |
| InterDigital | Support. However, not sure if it is needed. When using precompensation, the conclusion would be always respected by implementation. |
| Apple | We are fine with the FL proposal |
| Sony | Support the FL proposal. |
| DOCOMO | We are fine with the proposal. |
| OPPO | Support the proposal. |
| vivo | Support the proposal |
| Lenovo/MotM | We believe this issue is related to Issues #3-2. We believe linking the SRS with reference TRS for pre-compensation is needed, under which the QCL association would be pre-defined. |
| MediaTek | Support the proposal |
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### Issue #3-5 (Support of TRP-based pre-compensation dynamic switching)

One company proposed to clarify configuration restriction for UE not capable of supporting dynamic switching between TRP based pre-compensation and single TRP by TCI field in DCI format 1\_1/1\_2 similar to configuration restriction agreed for scheme 1. The corresponding proposal is provided below.

#### Round-1

**Proposal #3-5:**

* UE is not expected to be indicated by MAC CE with single TCI state for any of TCI codepoint, if UE is configured with TRP based pre-compensation for PDSCH by RRC, but not capable to support dynamic switching between TRP based pre-compensation and single-TRP by TCI state field in DCI Format 1\_1/1\_2.

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| **Company** | **Comment** |
| Moderator | This should be straightforward clarification for TRP-based pre-compensation scheme given previous agreement on support of dynamic switching based on UE capability |
| ZTE | What is the difference between the following agreement made in last meeting and the above proposal?  **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) |
| Apple | Support the FL proposal |
| Sony | Thanks to the quote from ZTE, we also think it’s quite straightforward and has been already supported. |
| DOCOMO | We don’t need the proposal. We already agreed it in RAN1#105, as ZTE commented above. |
| Lenovo/MotM | Agree with ZTE. We believe it is already supported |
| MediaTek | Support the proposal |
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### Other issues

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

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## SFN transmission of PDCCH

### Issue #4-1 (Activation of two TCI states across multiple CCs)

In RAN1#104b-e meeting several issues related to support of enhanced SFN PDCCH transmission were agreed for further study. Some companies provided their preference regarding these FFS issues.

**Issue #4-1:**

* In CA scenario additionally support RRC configured set of the serving cells which can be addressed by a single MAC CE entry
  + **Supported**: Qualcomm, Lenovo/MotMobility, Docomo …
  + **Concerns**: Intel

#### Round-1

Based on the above preference, the following proposal is made:

**Proposal #4-1:**

* In CA scenario additionally support RRC configured set of the serving cells which can be addressed by a single MAC CE entry

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| **Company** | **Comment** |
| ZTE | Is this intermitted from Rel-16 feature in which one MACCE can be used to update TCI of a list of CCs? If yes, we are OK. However, new RRC signaling is not needed. The existing one can be reused. Thus, we suggest   * In CA scenario, two TCI states can be updated/activated by a single MAC CE for a set of serving cells configured by existing RRC parameter *simultaneousTCI-UpdateList1* or *simultaneousTCI-UpdateList2* |
| Apple | We slightly do not prefer to mix the Rel-16 and Rel-17 feature together. In the other words, we do not prefer that for UEs who support Rel-16 single MAC-CE to update CORESET QCL in multiple CCs, automatically have to support it for Rel-17 HST (i.e., CORESET configured with two TCIs). We are open to discuss if it is separate UE capability and separately configured by the NW. |
| Sony | We are fine to reuse the Rel.16 RRC configured CC list(s) for common TCI state ID updating CORESETs beam. Would the proponent(s) or FL to clarity whether new CC list(s) are to be additionally introduced or reuse existing list(s)? |
| DOCOMO | Support ZTE’s update. We think separate Rel.17 capability is needed, but we can reuse Rel.16 RRC parameter of *simultaneousTCI-UpdateList1 or simultaneousTCI-UpdateList2*. |
| Xiaomi | Support the proposal. Further discuss on reuse Rel-16 RRC or introduce a new RRC to configure a list of CCs. |
| OPPO | Generally we agree with apple. A separate UE capability may be needed.  One question for clarification: If SFN transmission of PDCCH is not configured in a CC in a CC list, but two TCI states are activated for the CC list, what is the UE assumption for PDCCH? |
| vivo | Agree with ZTE, prefer to reuse the Rel.16 mechanism. |
| Lenovo/MotM | Support FL proposal. We are also fine with ZTE’s clarification and modified version for configuration simplicity |
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### Issue #4-2 (Default TCI for single-beam PDSCH)

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

**Issue #4-2:**

If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP-based pre-compensation) is configured and UE is configured with Rel-15 single-TRP or Rel-16 scheme 3/4 PDSCH scheme and CORESET is indicated with two TCI states and UE is not configured with *enableTwoDefaultTCI-States* and time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*

* **Alt 1**: gNB ensures the lowest CORESET ID in the latest slot only configured with one TCI state by implementation
* **Alt 2**: Modify the definition of the lowest CORESET ID in the latest slot, e.g., the lowest CORESET ID among the CORESETs associated with one TCI state in the latest slot
  + **Supported**: Samsung, CATT, Lenovo/MotMobility
* **Alt 3**: QCL assumption associated with one TCI state of the lowest CORESET ID in the latest slot, if there are two activated TCI states for the CORESET with the lowest CORESET ID, one of two TCI states will be selected, e.g. always selects the first or the second TCI state or the TCI state with a lower ID
  + **Supported**: Samsung, CATT (in case all CORESETs has two TCI states), Lenovo/MotMobility, Ericsson, LGE, Xiaomi, Convida Wireless, Nokia/NSB, Spreadtrum
* FFS whether it is optional feature

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

#### Round-1

**Proposal #4-2:**

If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP-based pre-compensation) is configured and UE is configured with Rel-15 single-TRP or Rel-16 scheme 3/4 for PDSCH scheme and CORESET is indicated with two TCI states and UE is not configured with *enableTwoDefaultTCI-States* and time offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*

* **Alt 3**: QCL assumption associated with one TCI state of the lowest CORESET ID in the latest slot, if there are two activated TCI states for the CORESET with the lowest CORESET ID, one of two TCI states will be selected, e.g. always selects the first or the second TCI state or the TCI state with a lower ID
* FFS whether it is optional feature

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

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| **Company** | **Comment** |
| ZTE | OK |
| Apple | We haven’t even agreed to support this mixed scenario.  If it is agreed, for scheme 3/4, we need two QCL since it is mTRP TDM scheme, why the default beam is only one  Lastly, default beam requires UE to buffer which is extremely power/memory inefficient without noticeable user experience enhancement, we prefer it to be UE optional feature |
| DOCOMO | Fine. |
| Xiaomi | Support the proposal#4-2 |
| OPPO | We need to conclude on issue#1-4 first. If a common RRC parameter is used for PDSCH and PDCCH, there is not the case at all. |
| vivo | Prefer Alt 3, but we can discuss it after issue#1-4 about which mixed scenario would be supported. |
| Lenovo/MotM | Support |
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### Issue #4-3 (Default TCI for Rel-17 SFN PDSCH)

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

**Issue #4-3:**

If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP-based pre-compensation) is configured and 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:

* **Alt 1**: Reuse rule to determine TCI states as defined for Rel-16 PDSCH scheme-1a
  + **Supported**: Huawei/HiSilicon, Samsung, NEC, Qualcomm, Ericsson, Xiaomi, Spreadtrum
* **Alt 2**: Introduce new rules to determine TCI states based on two TCI state(s) of the CORESET
  + FFS other details
  + **Supported**: CATT, Intel, LGE

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

#### Round-1

**Proposal #4-3:**

If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP -based pre-compensation) is configured and 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:

* **Alt 1**: Reuse rule to determine TCI states as defined for Rel-16 PDSCH scheme-1a

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| **Company** | **Comment** |
| ZTE | In Rel-16, if UE is configured with  enableTwoDefaultTCI-States, the two TCI states from the lowest MACCE codepoint among ones with two TCI states are used as default beams. It is used for MTRP PDSCH schemes regardless of PDCCH scheme. Thus, the above proposal should be changed as  If enhanced SFN PDSCH transmission scheme (scheme 1 or TRP -based pre-compensation) is configured 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, to determine default beam(s) for Rel-17 SFN PDSCH reception:   * **Alt 1**: Reuse rule to determine TCI states as defined for Rel-16 PDSCH scheme-1a |
| Apple | In Rel-16, default beam is UE optional feature, i.e., FG16-2b-0. So we need the similar agreement and it is preferable to have independent UE capability |
| DOCOMO | Support FL proposal, with modifying ~~down-select rule~~. |
| Xiaomi | We are fine with Proposal #4-3 and DOCOMO’s modification |
| OPPO | We think HST-SFN should be supported with indicated TCI state. There are so many cases for default TCI state with HST-SFN(see issue #4-2~4-7, and there are many other cases not specified here). We don’t think there is enough time to discuss all the cases with conclusion. It is simpler to support it with scheduling offset larger than offset. |
| vivo | Support to reuse the Rel-16 rule to determine default TCI states for SFN PDSCH based on the lowest codepoint in MAC CE, and fine with ZTE’s modification. |
| Lenovo/MotM | Support the proposal |
| MediaTek | Support the proposal |

### Issue #3-4 (TCI states of PDSCH with absent TCI field)

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

**Issue #4-4**:

For PDSCH reception scheduled by DCI format 1\_1 and 1\_2, if a CORESET is indicated with two TCI states and the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL* down-select one alternative

* **Alt 1:** Support configuration when there is no TCI field in the DCI scheduling PDSCH
  + - if there is at least one TCI codepoint indicating two TCI states, UE applies the QCL assumption of the CORESET that schedules the PDSCH when receiving the PDSCH
    - otherwise, UE applies the first TCI state of the CORESET when receiving the PDSCH
  + FFS whether or not UE capability is required
    - **Supported**: CATT, Lenovo/MotMobility, LGE, DOCOMO, Convida Wireless
* **Alt 2**: Configuration when there is no TCI field in the DCI scheduling PDSCH is not supported
  + **Supported**: OPPO?, Qualcomm,

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

#### Round-1

**Proposal #4-4**:

For PDSCH reception scheduled by DCI format 1\_1 and 1\_2, if a CORESET is indicated with two TCI states and the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL* down-select one alternative

* **Alt 1:** Support configuration when there is no TCI field in the DCI scheduling PDSCH
  + - if there is at least one TCI codepoint indicating two TCI states, UE applies the QCL assumption of the CORESET that schedules the PDSCH when receiving the PDSCH
    - otherwise, UE applies the first TCI state of the CORESET when receiving the PDSCH
  + FFS whether or not UE capability is required

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| **Company** | **Comment** |
| ZTE | Why do we have to need the first subbullet? UE applies the QCL assumption of scheduling PDCCH anyway, there is no relationship with ‘at least one TCI codepoint indicating two TCI states’. So we suggest   * **Alt 1:** Support configuration when there is no TCI field in the DCI scheduling PDSCH   + - UE applies the first TCI state of the CORESET that schedules the PDSCH when receiving the PDSCH   + FFS whether or not UE capability is required |
| Apple | Do not support this proposal. We first need to even discuss if we allow HST-SFN DCI format 1\_1 and 1\_2 to scheme sTRP PDSCH (which is the second bullet) |
| DOCOMO | * Support the proposal in principle, but in Rel.15/16, for DCI formats without TCI state field (including DCI format 1\_0/1\_1/1\_2), and if the scheduling offset is larger than *timeDurationForQCL*, QCL assumption of PDSCH is derived from the scheduling CORESET. We should reuse this basic rule. * In Rel.17, the scheduling CORESET may have one or two TCI states. So, we should cover the both cases. If one TCI state is derived, it means S-TRP PDSCH, otherwise, we should discuss the PDSCH with two TCI states are HST-SFN schemes in Rel.17 or M-TRP repetition schemes in Rel.16. * DCI format 1\_0 should be also covered in the proposal.   Hence, we suggest to update the proposal:  For PDSCH reception scheduled by DCI format 1\_0, 1\_1 and 1\_2, if a CORESET is indicated with two TCI states and the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL* down-select one alternative   * **Alt 1:** Support configuration when there is no TCI field in the DCI scheduling PDSCH   + - UE applies the state(s) of the CORESET when receiving the PDSCH   if there is 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 whether or not UE capability is required |
| Xiaomi | Support the proposal #4-4. While for Rel-16 scheme 3/4 for PDSCH, further discussion on how to apply two TCI states is needed. |
| OPPO | We don’t support the proposal.  Firstly, a CORESET should be “the scheduling CORESET”.  Secondly, we need to conclude on issue#1-4 first. If a common RRC parameter is used for PDSCH and PDCCH, the PDSCH would not be S-TRP transmission at all.  Thirdly, we don’t support the proposal of ZTE and DOCOMO. If the scheduling CORESET is configured with two TCI state, but PDSCH is configured with S-TRP/Rel-16 URLLC (if agreed by #1-4), UE needs to support dynamic switching following the proposal. It should be noticed that dynamic switching between Rel-16 URLLC and Rel-17 HST is not supported by current agreement. |
| Lenovo/MotM | We think “at least one TCI codepoint indicating two TCI states” is not needed. Thus, we suggest:   * **Alt 1:** Support configuration when there is no TCI field in the DCI scheduling PDSCH   + - if enableTwoDefaultTCI-States is configured, UE applies the QCL assumption of the CORESET that schedules the PDSCH when receiving the PDSCH     - otherwise, UE applies one TCI state of the CORESET when receiving the PDSCH   FFS whether or not UE capability is required |
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### Issue #4-5 (Default TCI for aperiodic CSI-RS)

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

#### Round-1

**Proposal #4-5:**

* If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP -based pre-compensation) 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 overlapping DL signal use one of two TCI states as default beam for aperiodic CSI-RS reception using the same principles as for default TCI state for Rel-15 single TRP PDSCH case

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| **Company** | **Comment** |
| ZTE | OK |
| Apple | *enableTwoDefaultTCI-States*  What is Rel-15 sTRP rule? Is it based on CORESET? But now CORESET has two TCI, but we do not support CSI-RS with two TCI |
| DOCOMO | Is it correct understanding to add “,” at the below location?  - If there is no other overlapping DL signal use one of two TCI states as default beam for aperiodic CSI-RS reception, using the same principles as for default TCI state for Rel-15 single TRP PDSCH case  Why the proposal only covers the case “if there is no other overlapping DL signal”? |
| Xiaomi | We are confused which TCI state will be applied for AP CSI-RS when CORESET configured with two TCI states. |
| OPPO | Similar to PDSCH, we propose to only support scheduling offset larger than threshold if the CORESET is configured with two TCI state. Then default TCI state is not needed to be defined. |
| vivo | Does it mean that one of the two TCI states associated with the lowest CORESET in the latest slot would be used as the default TCI state for the AP-CSI-RS, if yes, we support it. Furthermore, we prefer to define the first one of two TCI states as the default TCI state, which is similar to the mechanism of the default TCI state for AP-CSI-RS in Rel-16. |
| Lenovo/MotM | Support |

### Issue #4-6 (Default spatial / PL RS for single-TRP PUSCH/PUCCH/SRS)

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

#### Round-1

**Proposal #4-6:**

If enhanced SFN PDCCH transmission scheme (scheme 1 or TRP -based pre-compensation) is configured and CORESET is indicated with two TCI states for PUSCH/PUCCH/SRS transmission to a single-TRP

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

Companies to provide their preference on the proposal above.

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| **Company** | **Comment** |
| ZTE | Support in principle. |
| Apple | In Rel-16, this is an UE optional feature, i.e., FG16-1c. We also prefer it to be UE optional |
| DOCOMO | Support in principle. |
| Xiaomi | Support Proposal #4-6 |
| OPPO | We need to agree that the Rel-16 default spatial relation/PL RS for PUSCH/PUCCH/SRS is also applicable to HST-SFN transmission firstly. In Rel-16, default spatial relation/PL RS for PUSCH/PUCCH/SRS was only agreed for single TRP case. It needs to be clarified whether SFNed PDCCH transmission is an S-TRP case or M-TRP case?  **Agreement@RAN1#99**  The following working assumption is confirmed with revision in red  The default spatial relation for dedicated-PUCCH/SRS for a CC in FR2, at least when no pathloss RSs are configured by RRC is determined by   * ~~Default TCI state or QCL assumption of PDSCH, i.e.,~~ * in case when CORESET(s) are configured on the CC, the TCI state / QCL assumption of the CORESET with the lowest ID, or   + The PL RS to be used is the QCL-TypeD RS of the same TCI state / QCL assumption of the CORESET with the lowest ID   + Note: The PL RS should be periodic RS * in case when any CORESETs are not configured on the CC, the activated TCI state with the lowest ID applicable to PDSCH in the active DL-BWP of the CC * Above applies at least for UEs supporting beam correspondence * Above applies at least for the single TRP case4 |
| vivo | Support the proposal |
| Lenovo/MotM | Support |
| MediaTek | Support |
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### Issue #4-7 (Default spatial / PL RS for Rel-17 multi-TRP PUSCH/PUCCH)

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

#### Round-1

**Proposal #4-7:**

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

Companies to provide their views on the proposal above.

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| **Company** | **Comment** |
| ZTE | Support. |
| Apple | Firstly, we need an agreement whether this is supported, i.e., mixture of HST-SFN PDCCH with other mTRP scheme that is non-HST |
| DOCOMO | Support. |
| Xiaomi | This can be discussed later. Since the default beams and PL RS for Rel-17 Multi-TRP PUSCH/PUCCH repetition scheme with Rel-16 CORESET is not decided yet. |
| OPPO | In Rel-16, default spatial relation/PL RS for PUSCH/PUCCH/SRS was only agreed for single TRP case. It needs to be clarified that   1. Whether SFNed PDCCH transmission is an S-TRP case or M-TRP case? 2. Whether Rel-17 multi-TRP PUSCH/PUCCH is a single TRP case?   If not, we need a new agreement that Rel-16 default spatial relation/PL RS for PUSCH/PUCCH is also applied to multiple TRP case. But maybe 8.1.2.1 is the right place to make this agreement.  **Working Assumption@RAN1#98bis**  The default spatial relation for dedicated-PUCCH/SRS for a CC in FR2, at least when no pathloss RSs are configured by RRC is determined by   * Default TCI state or QCL assumption of PDSCH, i.e.,   + in case when CORESET(s) are configured on the CC, the CORESET with the lowest ID in the most recent monitored downlink slot, or   + in case when any CORESETs are not configured on the CC, the activated TCI state with the lowest ID applicable to PDSCH in the active DL-BWP of the CC * Above applies at least for UEs supporting beam correspondence * Above applies at least for the single TRP case * FFS: Details on UE behavior in the absence of the activated TCI state * FFS: Details on default spatial relation in multicarrier scenario * FFS: Details on which RS to use for pathloss measurement * FFS: Details on how to handle this issue in case pathloss RSs are configured   **Agreement@RAN1#99**  The following working assumption is confirmed with revision in red  The default spatial relation for dedicated-PUCCH/SRS for a CC in FR2, at least when no pathloss RSs are configured by RRC is determined by   * ~~Default TCI state or QCL assumption of PDSCH, i.e.,~~ * in case when CORESET(s) are configured on the CC, the TCI state / QCL assumption of the CORESET with the lowest ID, or   + The PL RS to be used is the QCL-TypeD RS of the same TCI state / QCL assumption of the CORESET with the lowest ID   + Note: The PL RS should be periodic RS * in case when any CORESETs are not configured on the CC, the activated TCI state with the lowest ID applicable to PDSCH in the active DL-BWP of the CC * Above applies at least for UEs supporting beam correspondence * Above applies at least for the single TRP case |
| vivo | Support |
| Lenovo/MotM | Support |
| MediaTek | Support |
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### Issue #4-8 (PDCCH monitoring with different QCL-TypeD)

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

**Issue #4-8:**

* When a CORESET is activated with two TCI states which overlaps with another CORESET, support Rel-15 prioritization rule for PDCCH monitoring of PDCCH candidates in overlapping monitoring occasions with different QCL-TypeD
  + **Alt 1**: Prioritization rule considers only CORESETs indicated with same number of TCI states (e.g., 2)
    - **Supported**: Qualcomm, Spreadtrum?
  + **Alt 2**: Prioritization rule considers CORESETs indicated with the same and different number of TCI states
    - FFS other details
    - **Supported**: Samsung, CATT, Lenovo/MotMobility, LGE, Xiaomi,

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

#### Round-1

**Proposal #4-8:**

* When a CORESET is activated with two TCI states which overlaps with another CORESET, support Rel-15 prioritization rule for PDCCH monitoring of PDCCH candidates in overlapping monitoring occasions with different QCL-TypeD
  + Prioritization rule considers CORESETs indicated with the same and different number of TCI states
    - FFS other details

Companies to provide their views on the proposal above.

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| **Company** | **Comment** |
| ZTE | Support in principle.  For the details, we think:  The first QCL type D is identified by a first CORESET with highest priority based on Rel-15 rule (CSS in lowest CC wit highest priority, etc.). If the CORESET has two TCI states, the second QCL type D is also from the CORESET. Otherwise, the second QCL type D is identified by the first TCI of a second CORESET with second highest priority based on Rel-15 rule.  Thus, our suggestion is   * When a CORESET is activated with two TCI states which overlaps with another CORESET, support Rel-15 prioritization rule for PDCCH monitoring of PDCCH candidates in overlapping monitoring occasions with different QCL-TypeD   + The first QCL type D is identified by a first CORESET with highest priority based on Rel-15 rule (CSS in lowest CC wit highest priority, etc.). If the CORESET has two TCI states, the second QCL type D is also from the CORESET. Otherwise, the second QCL type D is identified by the first TCI of a second CORESET with second highest priority based on Rel-15 rule |
| Apple | We first need to discuss if this is even allowed, i.e., HST-SFN CORESET to be configured together with sTRP CORESET. The current specification is not broken neither in principle in 38.213 |
| Sony | We share same view as Apple that we may first need to discuss whether such CORESETs collision between SFN PDCCH and other PDCCH. If yes, then we go next level of details to determine the priority rules on CORESETs with same and/or different number of TCI states. |
| DOCOMO | Support the FL proposal. |
| Xiaomi | We support the FL proposal and we are also fine with the suggestion from Apple and Sony that in which scenario PDCCH candidate from both SFN PDCCH and sTRP PDCCH are overlapped should be discussed first. After that, we can discuss the rule for two QCL Type D determination. |
| OPPO | We need to discuss issue 1-4 and 1-3 firstly |
| vivo | We can discuss it later. |
| Lenovo/MotM | Support the proposal. We have the similar view to reuse Rel.15 rule as much as possible. Furthermore, we want to clarify whether two search space sets can be monitored simultaneously, where only one activated TCI state but different QCL-TypeD property is associated with each search space set. |
| MediaTek | Support |
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### Applicability of the enhanced SFN transmission scheme for common PDCCH

A few companies have raised the issue of supporting enhanced SFN transmission scheme (e.g., TRP based pre-compensation) for common PDCCH as well as for PDSCH scheduled by CSS. Given that such transmissions are likely to be broadcast, NW may not support transmission with pre-compensation. Companies are invited to share their views regarding support of such scenarios including related enhancements or restrictions.

#### Round-1

Proposal #4-9:

* Study applicability of enhanced SFN transmission with TRP based pre-compensation to CORESETs associated with CSS
* Study applicability of enhanced SFN transmission with TRP based pre-compensation to PDSCH scheduled by CSS

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| **Company** | **Comment** |
| ZTE | Support study. However, for the second bullet, it seems not easy to be supported. |
| Apple | We are fine to study |
| Sony | Fine to study |
| DOCOMO | Fine to study. |
| Xiaomi | Fine to study. |
| OPPO | Support to study the issue. |
| vivo | We are fine to study |
| Lenovo/MotM | Support to study |
| MediaTek | Fine to study |
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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

### Issue #5-1 (Configuration of RS for BFD)

Several companies have discussed the issue of reference signals configuration for beam failure detection (BFD), when two TCI states are activated for CORESET. Based on the company’s contributions the following preference on the agreed alternatives from RAN1#105e meeting are provided.

**Issue #5-1:**

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
    - **Supported**: vivo, InterDigital (optional feature), CATT, Lenovo/MotMobility, Apple, DOCOMO, Xiaomi, Convida Wireless, Nokia/NSB, ZTE
  + **Alt 1-3**: RS of CORESETs with only two TCI states are used
    - **Supported**: vivo, InterDigital, NEC, Qualcomm,
* Down-select one alternative for explicit configuration
  + **Alt 2-1**: Support defining CSI-RS resource or SSB pairs as BFD RS
    - FFS other details
    - **Supported**: InterDigital, CATT, Lenov/MotMobility, Apple, Xiaomi, Intel, ZTE
  + **Alt 2-2**: Reuse the existing Rel-15/Rel-16 approach for BFD RS configuration
    - **Supported**: Huawei/HiSilicon, Qualcomm, DOCOMO, Convida Wireless, Nokia/NSB, Spreadtrum
* 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

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

#### Round-1

Proposal #5-1:

* TBD

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| **Company** | **Comment** |
| OPPO | Support Alt 1-2 and 2-2. |
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### Issue #5-2 (Hypothetical BLER calculation for BFD)

Several companies have discussed the issue of hypothetical BLER calculation using measurements from beam failure detection (BFD) RS, when two TCI states are activated for CORESET. Based on the company’s contributions the following preference on the agreed alternatives from RAN1#105e meeting are provided.

**Issue #5-2:**

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

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

#### Round-1

**Proposal #5-2:**

* TBD

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| **Company** | **Comment** |
| ZTE | It seems FL didn’t capture our views from our tdoc in the FL summary.  We support Alt3-2 as it reflects the real PDCCH transmission. Alt 3-1 will cause the unnecessary BFR report when only one beam just fails. |
| Sony | Support Alt 3-2 which facilitates UE to calculate BLER of actually SFN PDCCH. |
| DOCOMO | Support Atl.3-2. Since PDCCH is received in SFN, BLER of PDCCH should be also calculated with SFN assumption. |
| OPPO | Support Alt 3-2. |
| vivo | Support Alt 3-2, calculating hypothetical BLER using BFD RS pairs would be more appropriate to reflect the performance of SFN-based PDCCH. |
| MediaTek | Support Alt 3-2 |
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### Issue #5-3 (NBI RS)

Several companies have discussed the issue of configuration of new beam identification reference signals, when two TCI states are activated for CORESET. Based on the company’s contributions the following preference on the agreed alternatives from RAN1#105e meeting are provided.

**Issue #5-3:**

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

#### Round-1

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

**Proposal #5-3:**

* TBD

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| **Company** | **Comment** |
| Sony | We think legacy NBI configuration (Alt 4-1) could work. In addition, if the BFR of SFN transmission occur, UE doesn’t necessarily recover back to SFN operation. At current moment, it is still possible for UE to fall back to S-TRP mode. Perhaps this needs more discussion. |
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### Issue #5-4 (Applicability of the BFR enhancements)

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

**Issue #5-4:**

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

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

#### Round-1

**Proposal #5-4:**

* When two TCI states are activated for a CORESET, BFR enhancements are applicable to
  + Rel-15 BFR and Rel-16 BFR procedure

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| **Company** | **Comment** |
| Moderator | Can be discussed later |
| ZTE | Support |
| Apple | Can be discussed later and we also need to consider the other BFR enhancement in the mTRP PDCCH enhancement session |
| Docomo | Support |
| Xiaomi | Further discussion on details is necessary. |
| Lenovo/MotM | Support |
| MediaTek | Fine to discuss later |
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## Other issues

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

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| **Company** | **Comment** |
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## Radio Link Monitoring

### Issue #6-1

One company raised issue of RLM RS set configuration for enhanced SFN transmission scheme of PDCCH. It is proposed to further discuss this issue in the next RAN1 meetings.

#### Round-1

**Proposal #6-1:**

* Study RLM RS configuration enhancements when enhanced SFN transmission scheme is configured for PDCCH

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| **Company** | **Comment** |
| ZTE | Support |
| Apple | Discuss later |
| Docomo | Support |
| |  |  | | --- | --- | | OPPO | Support | | Support |
| Lenovo/MotM | Support |
| MediaTek | Support |
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## Issue #7-1 (Other non-categorized proposals)

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

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

# Other issues

This section contains other issues the companies want to highlight.

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| **Company** | **Comment** |
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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] R1-2106467, Enhancements on HST multi-TRP deployment in Rel-17, Huawei, HiSilicon

[3] R1-2106545, Discussion on Multi-TRP HST enhancements, ZTE

[4] R1-2106575, Further discussion and evaluation on HST-SFN schemes, vivo

[5] R1-2106644, M-TRP Operation for HST-SFN Deployment, InterDigital, Inc.

[6] R1-2106689, Discussion on enhancements on HST-SFN deployment, Spreadtrum Communications

[7] R1-2106792, Enhancement on HST-SFN deployment, Sony

[8] R1-2106869, Enhancements on HST-SFN, Samsung

[9] R1-2106939, Enhancements on HST-SFN deployment for Rel-17, CATT

[10] R1-2107082, Enhancement to support HST-SFN deployment scenario, FUTUREWEI

[11] R1-2107146, Discussion on HST-SFN deployment, NEC

[12] R1-2107178, Enhancements for HST-SFN deployment, Lenovo, Motorola Mobility

[13] R1-2107207, Enhancements on HST-SFN deployment, OPPO

[14] R1-2107327, Enhancements on HST-SFN deployment, Qualcomm Incorporated

[15] R1-2107394, Enhancements on HST-SFN deployment, CMCC

[16] R1-2107488, Enhancements on HST-SFN deployment, MediaTek Inc.

[17] R1-2107574, Enhancements to HST-SFN deployments, Intel Corporation

[18] R1-2107625, Enhancement on HST-SFN deployment, Ericsson

[19] R1-2107722, Views on Rel-17 HST enhancement, Apple

[20] R1-2107818, Enhancements on HST-SFN deployment, LG Electronics

[21] R1-2107842, Discussion on HST-SFN deployment, NTT DOCOMO, INC.

[22] R1-2107897, Enhancements on HST-SFN operation for multi-TRP PDCCH transmission, Xiaomi

[23] R1-2108022, On Enhancements for HST-SFN deployment, Convida Wireless

[24] R1-2108056, 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 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 |