**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 transmissionii. 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  | No 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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### 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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### 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:**

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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,

Companies are invited to provide their views on this issue.

#### Round-1

**Proposal #1-4:**

* TBD

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| **Company** | **Comment** |
| Moderator | The granularity of RRC configuration can be decided in RRC discussion sessions for Rel-17 |
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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 |
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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, …

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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| Moderator | This is a low priority issue |
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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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### 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, 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), Sony?, 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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### 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 (with SRS enhancements), 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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### 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 |
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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 #2-5:**

* 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 |
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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** |
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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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### 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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### 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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### 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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### 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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### 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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### 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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### 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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## Other issues

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

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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
	+ **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
	+ **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** |
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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, 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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### 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, NEC, CATT

#### Round-1

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

**Proposal #5-3:**

* TBD

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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 |
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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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## 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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## 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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[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.
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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
 |

**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
 |