**3GPP TSG RAN WG1 #103-e R1-200xxxx**

**e-Meeting, October 26th – November 13th, 2020**

**Source: Intel Corporation**

**Title: 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 proposal and FL 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]-[21] submitted to RAN1#103-e meeting.

## UE-based solutions

In RAN1#102-e meeting the following agreements were made regarding support of UE based solution for frequency offset compensation in HST-SFN scenario.

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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 |

## Issue #1-1 (Support of scheme 1)

Regarding support of scheme 1 in Rel-17. Several companies expressed their preference on this issue. Some companies also provided LLS results comparing performance of scheme 1 with the baseline transmission scheme. Summary of the company’s views on support of scheme 1 in Rel-17 is provided below:

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

* Scheme 1 is supported
	+ Futurewei, Huawei, ZTE, CATT (?), CMCC, Samsung, OPPO, Sony (?), Apple, LGE, Spreadtrum, DOCOMO (?), Qualcomm, Intel
* Scheme 1 is not supported
	+ vivo
* Further study support of scheme 1
	+ Nokia, Ericsson, Lenovo/MotM

Based on the company’s preference above, there is majority companies that prefers specification of scheme 1 in Rel-17 for HST-SFN scenario. Therefore, the following proposal is made:

**Proposal 1-1:**

* *Scheme 1 is supported in Rel-17*
	+ *DMRS port(s) can associate with multiple QCL/TCI*
	+ *FFS other details*

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## Issue #1-2 (Target physical channels)

Regarding target physical channels. Some companies provided their views regarding target physical downlink channels to supported for scheme 1 between the following options – PDSCH only or PDSCH + PDCCH. Summary of the company’s preference is provided below:

**Issue#1-2:** Physical channels that should be supported for scheme 1

* PDSCH only
	+ Huawei (?)
* PDCCH + PDSCH
	+ Futurewei, vivo, CMCC, Samsung, Sony, LGE, DOCOMO, Qualcomm (wait progress on mTRP PDCCH), Intel

Based on the company’s preference above, there is majority that prefers specification of scheme 1 for both PDSCH and PDCCH. Therefore, the following proposal is made:

**Proposal 1-2:**

* *Scheme 1 is supported for both PDCCH and PDSCH*

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## Issue #1-3 (Number of QCL/TCI for scheme 1)

Regarding the number of QCL/TCI that should be supported for scheme 1. Several companies provided their preference on this issue. Summary of the company’s views is provided below:

**Issue#1-3:** The number of QCL/TCI states supported in scheme 1

* At most two QCL/TCI states can be configured/indicated for scheme 1
	+ Futurewei, vivo, CATT, Samsung, OPPO, LGE, Spreadtrum, Qualcomm, Lenovo/MotM
* Two or more QCL/TCI states can be configured/indicated for scheme 1
	+ Intel, DOCOMO (?)
* Further study
	+ Ericsson

Based on the company’s preference above, there is majority that prefers support of at most two QCL/TCI states for scheme 1. Therefore, the following proposal is made:

**Proposal 1-3:**

* *At most two QCL/TCI states are supported for scheme 1*

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## Issue #1-4 (Indication of scheme 1/2)

Regarding configuration or switching of scheme 1. Several companies provided their preference regarding support of dynamic switching between scheme 1 / scheme 2 (if supported) and Rel-16 non-SFN schemes. Summary of the company’s preference is provided below:

**Issue#1-4:** How to support configuration / switching between Rel-17 scheme 1 or scheme 2 (if supported) and Rel-16 schemes?

* DCI
	+ Futurewei, vivo, Samsung, LGE, Qualcomm
* MAC CE
	+ Futurewei
* RRC
	+ Futurewei, InterDigital, ZTE, CMCC, OPPO, Ericsson, Lenovo/MotM, Spreadtrum, Qualcomm

Given the views above, there is no majority to support DCI based switching in RAN1#103-e. At the same time, it should be common understanding that at least some RRC signalling is required to enable scheme 1 or scheme 2 (if supported). Therefore, the following proposal is made:

**Proposal 1-4:**

* *At least RRC is used to enable scheme 1 and scheme 2 (if supported)*
	+ *FFS whether or not DCI based dynamic switching with Rel-16 non-SFN scheme(s) is supported*
	+ *FFS which Rel-16 non-SFN schemes should be supported for dynamic switching*
	+ *Note: Support of scheme 1 or scheme 2 is a different issue and should be discussed separately*

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## Issue #1-5 (QCL relationship between TRS and DMRS ports)

On the aspect of “QCL relationship between TRS and DMRS ports”, one company [7] proposed to extend definition of QCL to support QCL association of one antenna port (e.g., DM-RS) and antenna port group (e.g., TRS).

**Issue#1-5:** Whether or not to modify QCL definition to support QCL association relationship of one antenna port and one antenna port group?

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| Antenna port x and antenna port group y are said to be quasi co-located if the large-scale properties of the channel over which a symbol on antenna port x is conveyed can be inferred from the combination of channels over which the symbols on the antenna ports of the antenna port group y is conveyed. The large-scale properties include one or more of delay spread, Doppler spread, Doppler shift, average gain, average delay, and spatial Rx parameters. |

This aspect has been listed as open issue from RAN1#102-e meeting. It is recommended to have further discussion on this issue.

**Proposal 1-5:**

* *Companies to provide their views on this issue.*

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## Issue #1-6 (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 demonstrated LLS evaluation results comparing performance of scheme 2 with scheme 1 and the baseline scheme. Summary of the company’s views is provided below:

**Issue#1-6:** Whether to support scheme 2 in Rel-17?

* Scheme 2 is supported
	+ InterDigital, NEC, LGE, Lenovo/MotM, Intel
* Scheme 2 is not supported
	+ Samsung, vivo, Qualcomm, OPPO
* Further study support of scheme 2
	+ Nokia, Ericsson

There is no clear majority to support scheme 2 in Rel-17 for this meeting. Therefore, it is recommended to further study support of scheme 2 in the next meetings with the aim to address some technical concerns (e.g., DM-RS overhead).

**Proposal 1-6:**

* *Further discuss the need of supporting scheme 2 in Rel-17 including possible DM-RS overhead reduction options*

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## NW based solutions

In RAN1#102-e meeting the following agreements were made regarding support of NW based solution for frequency offset compensation in HST-SFN scenario.

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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
* Signaling/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 |

## Issue #2-1 (Support of TRP-based pre-compensation)

Regarding support of TRP-based pre-compensation schemes in Rel-17. Several companies expressed their views on this issue. Some companies have also provided LLS results comparing performance of TRP based pre-compensation with the baseline transmission scheme. Summary of the company’s preference is provided below:

**Issue#2-1:** Whether to support specification based TRP pre-compensations?

* TRP-based frequency offset pre-compensation is supported in Rel-17
	+ Futurewei, Huawei, vivo, ZTE, CATT, CMCC, Samsung, OPPO, Apple, LGE, NEC, Spreadtrum
* TRP-based frequency offset pre-compensation is not supported in Rel-17
	+ LGE
* Further study support of TRP-based frequency offset pre-compensation in Rel-17
	+ Nokia, Ericsson, Qualcomm, Lenovo/MotM

Based on the company’s preference above, there is majority that prefers specification of TRP-based frequency offset compensation in Rel-17 for HST-SFN scenario. Therefore, the following proposal is made:

**Proposal 2-1:**

* *TRP-based pre-compensation is supported in Rel-17*
	+ *FFS other details*

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## Issue #2-2 (Indication of of the carrier frequency for UL)

Regarding indication of the carrier frequency for UL transmission. Several companies expressed their views regarding this issue. Companies preferences are summarized below:

**Issue#2-2:** Indication of carrier frequency for TRP-based pre-compensation

* Option 1 (implicit) from RAN1#102-e agreement
	+ Futurewei, Huawei, vivo, ZTE, CATT, CMCC, Samsung, OPPO, Apple, LGE, NEC, Lenovo/MotM, Spreadtrum, Qualcomm
* Option 2 (explicit) from RAN1#102-e agreement
	+ Apple, Sony, Ericsson, Qualcomm
* Further study
	+ Nokia

Based on majority view, the following proposal is made:

**Proposal 2-2:**

* *Implicit approach (i.e., Option 1 from RAN1#102-e agreement) is used for indication of carrier frequency*
	+ *FFS whether or not it has any spec impact and details of possible specification support*

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## Issue #2-3 (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 expressed their views whether it requires specification support or can be up to UE implementation. Companies views on this issue are summarized below:

**Issue#2-3:** Whether to support QCL-like association between DL and UL RS?

* QCL-like association of the resource(s) received in the 1st step with UL signal transmitted in the 2nd step is supported by specification
	+ Futurewei, Huawei, IterDigital (?), CMCC, OPPO, Sony, Nokia (if supported), Intel, Spreadtrum, Qualcomm
* 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
	+ vivo, CATT, Samsung, LGE, NEC(?)

Based on majority view, the following proposal is made

**Proposal 2-3:**

* *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 detailed solution*

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## Issue #2-4 (QCL types/assumptions when TRS is source)

Regarding new QCL types/assumption for TRS with other RS (e.g., DM-RS), when TRS resource(s) is used as source RS in the TCI state. The following variants of QCL types/assumption were proposed by companies.

**Issue#2-4:** Possible variants of new QCL types/assumption for TRS for specification in Rel-17

* **Variant A**: 1st TRS is used for estimation of {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA) and the 2nd TRS is used for estimation of {*average delay, delay spread*} (i.e., new QCL-Type-TBD)
	+ CMCC, Sony, Huawei, ZTE, CMCC, Sony
* **Variant B**: 1st TRS is used for estimation of {*average delay, delay spread*} (i.e., QCL-Type-TBD1) and the 2nd TRS for estimation of {*Doppler shift, Doppler spread*} (i.e., QCL-Type-TBD2)
	+ CATT, Sony(?), Intel, Ericsson (? and if supported)
* **Variant C**: 1st TRS is used for estimation of {*average delay, delay spread, Doppler shift, Doppler spread*} (i.e., QCL-TypeA) and the 2nd TRS is used for estimation of {*delay spread*} (i.e. new QCL-Type-TBD)
	+ vivo
* **Variant D**: Specify that for TCI state related to the 2nd TRS, i.e., UE ignores {*Doppler shift, Doppler spread*} in the (i.e., QCL-TypeA) of TCI state, without defining new QCL types
	+ vivo, Sony

Based on the company’s preference above, the following proposal can be made:

**Proposal 2-4:**

* *New QCL types/assumption for TRS with DM-RS (when TRS resource(s) is used as source RS in the TCI state) is supported in Rel-17*
	+ *FFS which variant or combination of variants should be specified in Rel-17*

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## Issue #2-5 (QCL types when TRS is target)

Regarding 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. Two companies proposed to introduce new QCL type to account possibly different Doppler shift and Doppler spread characteristics between source RS and the target RS [9][21].

**Issue#2-5:** Support of new QCL type (e.g., loose Doppler shift relationship) between the TRS (including aperiodic TRS) and source RS (e.g., SSB or periodic TRS)

**Proposal 2-5:**

* *Companies to provide their views on necessity of the corresponding enhancement*

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## Issue #2-6 (Target physical channels)

Regarding target downlink physical channels that can be used with TRP-based pre-compensation. Some companies provided their preference on this issue between the following options – PDSCH only or PDSCH + PDCCH. Summary of the company’s views is provided below:

**Issue#2-6:** Physical channels and reference signal that should be supported for TRP-based pre-compensation

* PDSCH only
	+ CMCC (?)
* PDCCH + PDSCH
	+ Futurewei, vivo, Samsung, LGE, NEC, Intel
* Further study
	+ OPPO

**Proposal 2-6:**

* *TRP-based pre-compensation is supported for both PDCCH and PDSCH*

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## Issue #2-7 (2nd set TRS with pre-compensation)

Regarding support of pre-compensated TRS in 3rd step. The following views were provided by companies.

**Issue#2-7**: Whether to support frequency offset pre-compensation on TRS in 3rd step

* Supported: Futurewei, Samsung, Ericsson (?)
* Not supported: vivo, Intel, CATT, OPPO, Nokia

Based on the views above the following proposal is made

**Proposal 2-7:**

* *Further study necessity and specification impact of supporting frequency offset pre-compensation on TRS*

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## Issue #2-8 (Configuration of TRP pre-compensation)

Similar to scheme 1/2, the issue of configuration of TRP pre-compensation scheme and dynamic switching with other schemes should be addressed.

**Issue#2-8:** How to support configuration of TRP pre-compensation including dynamic switching with other schemes?

**Proposal 2-8:**

* *Companies to provide their views on this issue*

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## Issue #3-1 (Refinements to EVM)

Two companies provided discussion on EVM refinement for HST-SFN evaluations [16][17] with the following proposals:

* A 4-tap extended CDL channel model is necessary to capture the potential inter-symbol interference for the agreed TRP layout and SCS=30kHz
* SNR values of {8, 12, 16, 20} dB are not applicable to CDL channel model and should be recommended only for 4-tap channel model
* Three antenna panels at the UE should be used for FR2 evaluation. Consider evaluation of different antenna array orientation options in the azimuth domain
	+ Random orientation with uniform distribution
	+ Pre-determined with bore-sight direction of {300, 1500, -900} relative to train direction

**Proposal 3-1:**

* *Companies to provide their views on the above proposals.*

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## Issue #4-1 (Other non-categorized proposals)

Some aspects proposed by companies doesn’t have specific categorization and provided below for other company’s reference. It is proposed to consider the following enhancements in the next RAN1 meetings.

* *Study zone-based configuration for TCI/QCL information to mitigate potential high signaling overhead.*
* *Support new QCL information indicating opposite polarity of Doppler shift between different transmissions.*
* *Support variable-rate TRS transmission for HST deployment scenario.*
* *Support distributed CSI-RS and CSI feedback operation*
* *TCI states configured in non-serving cell(s) with PCI either explicitly configured or implicitly associated*
* *Support of unified TCI state in DCI to trigger SP/AP-TRS followed by SP/AP-SRS*
* *Introduce a UE assisted DMRS adaptation for DL, in which UE provides an indication of the most convenient DMRS configuration option per estimated channel and SNR conditions*
* *Introduce a new mechanism for dynamic DMRS configuration signaling to enable DMRS adaptation.*
* *Introduce new SRS pattern for UL Doppler estimation purpose, comprised of two non-consecutive SRS symbol repetition with configurable time gap between the symbols*

**Proposal 4-1:**

* *Consider the above enhancements in the future RAN1 meetings*

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# Other issues

This section contains other issues the companies want to highlight.

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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] R1-2007543, Enhancement to support HST-SFN deployment scenario, FUTUREWEI

[3] R1-2007590, Discussion on multi-TRP for high speed train in Rel-17, Huawei, HiSilicon

[4] R1-2007630, Enhancements for M-TRP to Support HST-SFN Deployment, InterDigital, Inc.

[5] R1-2007648, Further discussion and evaluation on HST-SFN schemes, vivo

[6] R1-2007767, Discussion on Multi-TRP HST enhancements, ZTE

[7] R1-2007828, On enhancements on HST-SFN deployment, CATT

[8] R1-2008004, Enhancements on HST-SFN deployment, CMCC

[9] R1-2008152, Enhancements on HST-SFN, Samsung

[10] R1-2008221, Enhancements on HST-SFN deployment, OPPO

[11] R1-2008350, Considerations on HST-SFN operation for multi-TRP, Sony

[12] R1-2008442, Views on Rel-17 HST enhancement, Apple

[13] R1-2008577, Enhancements on HST-SFN deployment, LG Electronics

[14] R1-2008907, Enhancements for HST-SFN deployment, Nokia, Nokia Shanghai Bell

[15] R1-2008947, Discussion on HST-SFN deployment, NEC

[16] R1-2008981, Enhancements to HST-SFN deployments, Intel Corporation

[17] R1-2009069, Enhancement on HST-SFN deployment, Ericsson

[18] R1-2009099, Enhancements for HST-SFN deployment, Lenovo, Motorola Mobility

[19] R1-2009145, Discussion on enhancements on HST-SFN deployment, Spreadtrum Communications

[20] R1-2009178, Discussion on HST-SFN deployment, NTT DOCOMO, INC.

[21] R1-2009254, Enhancements on HST-SFN deployment, Qualcomm Incorporated