**3GPP TSG RAN WG1 Meeting #102-e R1-200xxxx**

**e-Meeting, August 17th – 28th, 2020**

**Source: Intel Corporation**

**Title: Summary 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 proposal and FL proposals.

# Proposal on evaluations assumptions

## Evaluation assumptions for endorsement

During email discussion before RAN1#102-e meeting ([Rel.17 NR FeMIMO] Offline discussion on EVM - Phase 2 ITEM 2d) evaluation assumptions for HST-SFN deployment were discussed. Based on the discussion several aspects seem agreeable to all companies. It, therefore, proposed to agree on them as part of the below proposal.

**Proposal:**

* LLS to be used for Rel-17 HST evaluations
* Use bi-directional as mandatory and uni-directional as optional gNB antenna orientation
* Rel-15 SFN is used as the baseline for comparison. Performance comparison with other schemes (e.g., Rel-16 URLLC, DPS, etc.) can be also provided
* Adopt Table 1 for evaluation of HST-SFN deployment, except components highlighted in yellow
* Adopt CDL based channel model in Table 2 for HST-SFN evaluation

Table 1 LLS simulation assumption for HST-SFN deployment

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **FR1** | | **FR2** |
| Duplexing | FDD | TDD | TDD |
| TRP layout  (Ds, Dmin, etc) | Ds=700m, Dmin=150m  For CDL based model – RRH height: 35m, UE height: 1.5m | | Alt 2-3: Ds=200-300m, Dmin=30-50m  Alt 2-4: Ds=580m, Dmin=5m  RRH height: [5/10/15/20/35]m, UE height: 1.5m |
| gNB antenna configuration including number of antennas, pattern, ports, orientation, etc | 2 ports: [Mg, Ng, M, N, P]=[1, 1, 1, 1, 2],  4 ports: [Mg, Ng, M, N, P]=[1, 1, 1, 2, 2],  [8 ports: Mg, Ng, M, N, P]=[1, 1, 2, 2, 2]]  one-to-one mapping between antenna elements and TXRUs  omni-directional antenna  Note: The results for other antenna configurations can be also provided | | 2 ports: [Mg, Ng, M, N, P]=[1, 1, 4, 8, 2],  directional antenna  Note: The results for other antenna configurations can be also provided |
| UE antenna configuration including number of antennas, pattern, ports, orientation, etc | 2 ports: [Mg, Ng, M, N, P]=[ 1, 1, 1, 1, 2] or  4 ports: [Mg, Ng, M, N, P]=[1, 1, 1, 2, 2],  one-to-one mapping between antenna elements and TXRUs  omni-directional antenna | | 2 ports: [Mg, Ng, M, N, P]=[1, 1, 2, 4, 2],  directional antenna |
| DMRS type | Mandatory: DM-RS type 1  Optional: DM-RS type 2 | | |
| Number of DMRS symb. | 1+1+1 | | |
| TDD pattern | N/A | DDDDDDDSUU,  S: 6D 4G 4U | DDDDDDDSUU,  S: 6D 4G 4U |
| MCS | MCS 4/MCS 13/MCS 17 based on 64QAM table  Note: Companies can also provide results with MCS adaptation | | |
| Number of scheduled RBs | 10 or 50. Other values are optional. | | |
| Propagation condition | 4-tap channel model  (TS 36.101 (Annex B.3A) / TR 36.878)  Optional - CDL extension  (CDL D/E, DS = 100ns) | | CDL extension  (CDL D/E, DS = 20ns/30ns) |
| TRS configuration, TRS periodicity | 10ms, 2-slot pattern  Note: results for 20ms periodicity can be also provided | | |
| PDSCH mapping | Type A, Start symbol 2, Duration 12 | | |
| Rank | Rank 1  Optional: other ranks or rank adaptation | | |
| BW | 10 MHz or 20 MHz | | 20MHz or 50MHz or 80MHz |
| Carrier frequency or maximum Doppler shift | 2GHz,  350kmph or 500kmph | 3.5GHz,  350kmph or 500kmph | 30 GHz  200 kmph or 350kmph |
| Performance metric | Throughput; BLER | | |
| Other assumptions or simulation parameters, e.g., correlation | 1) SCS: 30kHz, 15kHz as optional  2) Note: precoding method should be provided by each company | 1) SCS: 30kHz  2) Note: precoding method should be provided by each company | 1) SCS: 120kHz  2) Note: precoding method and analog beamforming details should be provided by each company |

Table 2 CDL based channel model for HST-SFN deployment

|  |
| --- |
| CDL based channel model proposal for HST:  Combination of the CDL channel model in TR38.901 and the 4-tap channel model in TS36.101 Annex B.3A could be considered. As illustrated in figure below, 2-tap channel model for simplicity could be assumed which is similar to RAN4’s 4-tap assumption in order to reflect the characteristic of SFN-based transmission, and for each tap, CDL channel model in TR38.901 could be used to model the effect of the directional antenna of gNB.   * + The delay for k’th TRP is modified as   where is the delay of k’th TRP, which can be derived as  where is the delay of the n’th channel cluster as in Table 7.7.1-1~7.7.1-5 in 38.901 and assume the location of the k’th TRP is xk, and the UE’s location is y(t).  The delay spread for different TRPs could be modelled as different.   * + The normalized power for k’th TRP is modified as   FFS: Use of 3D distance for calculation of Pk   * + To generate the modified angle parameters, the scaling method mentioned in subclause 7.7.5.1 in TS 38.901 is used   where could be assumed, and of the k’th TRP is the AOD, AOA, ZOD and ZOA of LOS direction derived based on the locations and antenna heights of UE and TRPs.   * is the tabulated CDL ray angle * is the rms angular spread of the tabulated CDL including the offset ray angles, calculated using the angular spread definition in Annex A in TS 38.901 * is the mean angle of the tabulated CDL, calculated using the definition in Annex A in TS 38.901 * is the desired mean angle * is the desired rms angular spread * is the resulting scaled ray angle.   of the k’th TRP is the AOD, AOA, ZOD and ZOA of LOS cluster derived by the locations and antenna heights of UE and TRPs.  If is used to denote the distance between UE and TRP1.  For AOD1 of TRP1,  For AOA1 of TRP1,  For AOD2 of TRP2,  For AOA2 of TRP2,  For ZOD1 of TRP1,  For ZOD1 of TRP2,  For ZOA2 of TRP1 ,  For ZOA2 of TRP2,    Fig. 1. Simplified and updated HST-SFN channel model for evaluation  The gNB antenna boresight could direct to the middle point on the railway between two TRPs. CDL-D and CDL‑E channels models are recommended for evaluations. |

## Remaining issues related to evaluation assumptions

This section contains list of the aspects that were not resolved as part of email discussion. Companies are strongly encouraged to provide their views on the remaining issues.

## (Ds, Dmin) for TRP layout in FR2

Regarding (Ds, Dmin) for FR2, two alternatives were identified as more promising for the discussion. Companies are encouraged to provide their preference regarding proposal below.

**Proposal:**

* Down-select one of the options for HST evaluation in FR2
  + Option 1: Alt 2-3 from Table 1
  + Option 2: Alt 2-4 from Table 1
  + Option 3: Alt 2-3 or Alt 2-4 from Table 1 is reported by each company

|  |  |
| --- | --- |
| Company | Comment |
| Lenovo/MotM | We support Option 1. In our opinion, the too small Dmin in Option 2 (Alt 2-4) may be suitable for tunnel deployment, but not for outdoor railway. In case Option 3 is adopted, one alternative should be agreed to be mandatory to reduce the variation in simulation results across companies |
| InterDigital | Support Option 1 |
| ZTE | Support Option 1. But we also can accept option 3 |
| OPPO | Option 1. We don’t think current beam management framework can work in high speed with option 2. |
| CATT | Support Option 1. Since the path loss of FR2 is much larger than FR1, it is not reasonable to have similar Dmin in FR2 as in FR1.  In addition to that, the value of UE height might need to be reconsidered. 1.5m is the typical UE height for pedestrian user. However, in HST scenario, on top of subgrade and carriage floor, even for sitting users, 1.5m is not enough. |
| LG | We prefer Option 1. |
| Samsung | Support Option 2. The Dmin value for Option 2 considers practical deployment scenario for both outdoor and tunnel, where RRHs can be located at the poles along the railway. The distance between pole and railway would be few meters apart.    (Possible deployment for FR2, captured from R1-164029)  As a second preference, we are okay with Option 3. |
| Nokia/NSB | Option 3 |
| DOCOMO | Support option 2. Our most interesting scenario is in tunnel deployment (because we have plan to deploy new high speed train in Japan in 2027 and the max. commercial train speed is 500km/h and about 90% of all rail length is in tunnel). We suggest to take the more challenging scenario (in tunnel deployment), and if needed, we can consider the beam management enhancement. |

## RRHs height for TRP layout in FR2

There are several candidate values that were identified for RRHs height for FR2 evaluations. So far, companies, have not provided their preference regarding the specific value that should be used for evaluations. It is, therefore, proposed to do down-selection as part of this email discussion.

**Proposal:**

* Down-select RRHs height for FR2 evaluation from the following set – 5, 10, 15, 20, 35 m

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| --- | --- |
| Company | Comment |
| Lenovo/MotM | We support 20 m. for outdoor railway |
| InterDigital | We could consider a low and high value, for example, 10m and 35m |
| ZTE | Support 20m as our first preference. Other values except 5 is acceptable for us |
| OPPO | For outdoor, 5m is too small. |
| LG | Support 20m. |
| Samsung | As in the figure captured at the previous comment, the practical value for RRH height can be a few meters. We support 5 m. |
| Nokia/NSB | Support either 10 or 15m |
| DOCOMO | We support 5m because it is closer in tunnel deployment. |

## Number of TRP antenna ports for FR1 evaluations

There was proposal from several companies to also include 8 ports at TRP as part of evaluation assumption for HST.

**Proposal:**

* Include 8 ports at TRP for FR1 evaluations as mandatory configuration

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| --- | --- |
| Company | Comment |
| Lenovo/MotM | Support the FL proposal |
| InterDigital | Not sure if its needed for this evaluation |
| ZTE | 8 ports can be consider as an optional configuration |
| OPPO | 8 ports can be optional. |
| CATT | Not support. 2 and 4 ports are sufficient, not sure why 8 ports are needed. |
| LG | We prefer optional configuration for 8 ports. |
| Samsung | Prefer 8 ports as optional. |
| Nokia/NSB | We prefer 8 port to be optional. |
| DOCOMO | 4 port is enough. |

## Directional antenna pattern at TRP

There are two candidates for modeling of the directional antenna pattern at TRP. Companies are encouraged to provide their preference regarding the proposed options for both FR1 and FR2.

**Proposal:**

* Down-select one of the options for direction antenna modeling for FR1 and FR2
  + Option 1: Table 3 and Table 4
  + Option 2: Table 5
  + Option 3: Directional antenna modelling is reported by each company between Option 1 and 2

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| --- | --- |
| Company | Comment |
| Lenovo/MotM | We support Option 1. In case Option 3 is adopted, one alternative should be agreed to be mandatory to reduce the variation in simulation results across companies, otherwise it may be hard to draw unified conclusions based on simulation results. |
| InterDigital | Don’t support Option 3 |
| ZTE | Option 3. We don’t see much difference of the impact for simulation results |
| OPPO | Option 2. |
| CATT | Support Table 3. There is no conclusion on whether 8 ports are supported up to now. |
| LG | Option 2. |
| Samsung | Support Option 2. Option 1 has antenna radiation patterns for 2Tx and 8Tx only. If companies want to optionally present results for other number of Txs, the results could be diverging due to unaligned antenna pattern for them. |
| Nokia/NSB | Support option 2. |

Table 3 Antenna radiation pattern for TRP with 2Tx

|  |  |
| --- | --- |
| Parameter | Values |
| Antenna configuration | 2Tx: [Mg, Ng, M, N, P]=[1, 1, 1, 1, 2], one-to-one mapping between antenna elements and TXRUs |
| Vertical cut of the radiation power pattern (dB) for a single antenna element | with , and |
| Horizontal cut of the radiation power pattern (dB) for a single antenna element | with ,  and |
| 3D radiation power pattern (dB) for a single element |  |
| Maximum directional gain of an antenna element *GE,max* | 20.5 dBi |

Table 4 Antenna radiation pattern for TRP with 8Tx

|  |  |
| --- | --- |
| Parameter | Values |
| Antenna configuration | 8Tx: [Mg, Ng, M, N, P]=[1, 1, 1, 4, 2],  one-to-one mapping between antenna elements and TXRUs |
| Vertical cut of the radiation power pattern (dB) for a single antenna element | with , and |
| Horizontal cut of the radiation power pattern (dB) for a single antenna element |  |
| 3D radiation power pattern (dB) for a single element |  |
| Maximum directional gain of an antenna element *GE,max* | 17.5 dBi |

Table 5 Antenna radiation pattern for TRP

|  |  |  |
| --- | --- | --- |
| **Radiation power pattern of a single antenna element for RRH** | Vertical cut of the radiation power pattern (dB) |  |
| Horizontal cut of the radiation power pattern (dB) |  |
| 3D radiation power pattern (dB) |  |
| Maximum directional gain of an antenna element *GE,max* | 8 dBi |

## Directional antenna pattern at UE

Direction antenna pattern at the UE for FR2 is not defined. Although there was no specific proposal from companies regarding this issue, it is proposed to reuse already available model from TR 38.802.

**Proposal:**

* Adopt direction antenna model in Table 6 based on TR 38.802

Table 6 Antenna radiation pattern for UE

|  |  |
| --- | --- |
| Parameter | Values |
| **Antenna element radiation pattern in**  **dim (dB)** |  |
| **Antenna element radiation pattern in**  **dim (dB)** |  |
| **Combining method for 3D antenna element pattern (dB)** |  |
| **Maximum directional gain of an antenna element *GE,max*** | 5dBi |

|  |  |
| --- | --- |
| Company | Comment |
| InterDigital | Support FL proposal |
| ZTE | OK |
| OPPO | OK |
| CATT | Support |
| LG | Support |
| Samsung | Support |
| Nokia/NSB | Support |

## TRP antenna orientation

There are two candidates for TRP antenna orientation in HST-SFN deployment. Companies are encouraged to provide their preference regarding the proposed options.

**Proposal:**

* Down select one of the options for TRP antenna orientation:
  + Option 1
    - Antenna horizontal half power beam direction points to the midpoint between the two TRPs
      * FFS which side of HPBW should be used as reference
    - Antenna vertical upper half power beam direction points to the midpoint between the two TRPs
  + Option 2
    - Antenna downtilt and azimuth directions point to the midpoint between the two RRHs
  + Option 3 TRP antenna orientation is reported by each company between Option 1 and Option 2

|  |  |
| --- | --- |
| Company | Comment |
| Lenovo/MotM | We support Option 2. |
| InterDigital | Support Option 2 with the following revision for better clarity   * + Option 2     - Antenna downtilt and azimuth directions point to the midpoint between the two TRPs |
| ZTE | Support Option 2 |
| OPPO | Support Option 2. |
| CATT | Support Option 2 |
| LG | Support Option 2. |
| Samsung | Support Option 2. |
| Nokia/NSB | Support Option 3 |

## TRP Synchronization

Several companies have mentioned the importance of synchronization impairments modelling especially for evaluation of the enhancements based on NW pre-compensation of the frequency offset at TRP. Some companies, however, expressed concerns on including impairments as part of assumptions due to lack of details. Based on the initial feedback received from companies, it seems difficult to agree on concrete impairment model as mandatory component, but it can be recommended for evaluations for verification of the scheme wrt to the corresponding impairments.

**Proposal:**

* It is recommended to use non-perfect time and frequency synchronization between the TRPs and UE, i.e., modeling of TPR CFO error (where CFO have temporal variation), UE receiver CFO, TRP timing errors should be considered
  + Additional details are provided by each company
  + Consider already available models in TR 38.101-1 and TR 38.104

|  |  |
| --- | --- |
| Company | Comment |
| Lenovo/MotM | We support the FL proposal. Uniform CFO value for TRP within ±0.1 ppm range and for UE ±0.1ppm w.r.t. DL frequency. CFO should be independent across TRPs |
| InterDigital | Given the fact that TRPs are all connected to a same BBU, and the dominant source of any residual frequency is the Doppler shift, we propose to assume perfect synchronization. |
| ZTE | The same view as Lenovo |
| OPPO | The same view as InterDigital. We think perfect synchronization should be assumed. |
| CATT | Support the proposal. |
| LG | We don’t think that this kind of agreement is needed. |
| Samsung | Consider perfect synchronization as basic simulation assumption.  We think the effect of CFO/timing error varies by deployment scenario, and can be even negligible for some cases, e.g., for RRHs sharing the common RU. So we don’t think the synchronization impairments have to be ‘recommended’ to consider. |
| Nokia/NSB | Same view as InterDigital. we have to prioritize the study on the different channel/propagation condition than any implementation issue. |

## Other issues related to evaluations assumptions

During email discussion before RAN1#102-e meeting ([Rel.17 NR FeMIMO] Offline discussion on EVM – Phase 2 ITEM 2d) additional issues were identified by companies to be considered as part of evaluation assumptions.

## SNR for evaluations

To facilitate comparison of the results among companies, it is proposed to consider pre-determined SNR values for evaluations. Companies are encouraged to provide feedback regarding corresponding proposal.

**Proposal:**

* Agree specific set of SNR values for comparison
  + SNR = 8, 12, 16, 20 dB

|  |  |
| --- | --- |
| Company | Comment |
| Lenovo/MotM | Support the FL proposal |
| InterDigital | Support the FL proposal |
| ZTE | We prefer to be reported by each companies. |
| OPPO | Support to be reported by companies |
| CATT | Fine to specify a set of SNR values for comparison. |
| LG | We have the same view with ZTE/OPPO. |
| Samsung | Prefer to be reported by companies |
| Nokia/NSB | Support the proposal. |

## Train positions for HST-SFN evaluation

To facilitate comparison of the results among companies, it is proposed to clarify representation of the performance results. Companies are encouraged to provide feedback regarding corresponding proposal.

**Proposal:**

* The results should be reported
  + Option 1: Per track location (at specific SNR)
    - Segmentation of Ds into 20 positions.
  + Option 2: Average throughput across all track locations vs SNR
  + Option 3: Throughput vs SNR at specific location (e.g. mid track point).
  + Option 4: Representation of the results are reported by company

|  |  |
| --- | --- |
| Company | Comment |
| MotM/Lenovo | We would like to propose a combination of Option 1 and 2, where UEs are located uniformly along the railway, with two regions defined: center region in which Ues are within Ds/4 m. from the closest TRP, and edge region where UE is within Ds/4 to Ds/2 m. from closest TRP. This alternative would provide less simulation comparison points (2 values for center and edge regions compared with 20 values in Option 1), with better illustration of cell-center vs. cell-edge performance compared with Option 2 |
| InterDigital | Option 3 |
| ZTE | Any other options are OK except Option 2 since it cannot show the performance comparison clearly. |
| OPPO | Option 4. |
| CATT | Option 2 and Option 3. Option 2 can show the average performance along the track, and option 3 can show the performance comparison for extreme conditions. |
| LG | Option 4. |
| Samsung | Support Option 1. Performance of HST depends on the location of train but option 2 or option 3 cannot present such dependency clearly.  On the number of segmentation in Option 1, we prefer it to be reported by each company. |
| Nokia/NSB | Support Option 1. But fewer position can be considered. |
| DOCOMO | Same view with ZTE |

## UE types

It was mentioned by some companies that different types of UE can be considered in HST-SFN deployments – CPE and UE inside train. It was proposed to clarify the type of the UE used in the evaluations and possible impact on channel model due to considered type of the UE.

**Proposal:**

* Companies are encouraged to provide more view on this issue and how different types of the UEs can be accounted in the model

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| --- | --- |
| Company | Comment |
| Lenovo/MotM | We believe such clarification may not be needed, the main impact of considering both types applies to the channel model; the 4-tap mandatory channel model fits CPE or Ues close to window, whereas optional CDL model fits Ues away from the window. Other implications on UE capability due to different UE types is out of scope of the WI, in our opinion. |
| InterDigital | There should be a distinction between a CPE-type UE that is installed on the roof, and a UE that is inside the train, as they call for different set of solutions and considerations. Discussion based on a CPE-type UE can be more straightforward, as it can be assumed that it could represent all Ues in the train, and perform many measurement tasks and reporting on their behalves. However, if Ues are assumed inside the train, the solutions need to be more UE-specific or per UE. |
| ZTE | We think it is unnecessary to discuss UE type since it doesn’t matter. The simulation assumption has included much enough. |
| OPPO | We don’t think it is needed. |
| CATT | The type of UE can be reflected by channel model. Discussion on this issue is not needed. |
| LG | We also think it is unnecessary. |
| Samsung | Current LLS assumption on UE is enough. |
| Nokia/NSB | This is not necessary. |
| DOCOMO | We don’t think it is needed. |

# Possible enhancements for HST-SFN deployment

The section summarizes company proposals regarding enhancements that can be considered for HST-SFN deployment. The proposals are based on the contributions [2]-[21] submitted to RAN1#102-e meeting.

## UE based solutions

To be added in Part 2 discussion

## NW based solution

To be added in Part 2 discussion

## Other enhancements

To be added in Part 2 discussion

# Other issues

This section contains other issues the companies want to highlight.

|  |  |
| --- | --- |
| Company | Comment |
|  |  |
|  |  |
|  |  |

# 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] R1-2005367, Evaluation and discussion on HST-SFN schemes, vivo

[3] R1-2005458, Discussion on Multi-TRP HST enhancements, ZTE

[4] R1-2005486, Enhanced M-TRP for HST-SFN, InterDigital, Inc.

[5] R1-2005564, Considerations on HST-SFN operation for multi-TRP, Sony

[6] R1-2005592, Enhancement to support HST-SFN deployment scenario, FUTUREWEI

[7] R1-2005687, Discussion on enhancements on HST-SFN deployment, CATT

[8] R1-2005753, Discussion on HST-SFN deployment, NEC

[9] R1-2005862, On HST SFN enhancements, Intel Corporation

[10] R1-2005925, Enhancements for HST-SFN deployment, Lenovo, Motorola Mobility

[11] R1-2005987, Enhancements on HST-SFN deployment, OPPO

[12] R1-2006132, Enhancements on HST-SFN, Samsung

[13] R1-2006204, Enhancements on HST-SFN deployment, CMCC

[14] R1-2006261, Discussion on enhancements on HST-SFN deployment, Spreadtrum Communications

[15] R1-2006394, Enhancements on Multi-TRP for high speed train in Rel-17, Huawei, HiSilicon

[16] R1-2006475, Enhancement on HST-SFN deployment, Ericsson

[17] R1-2006503, Views on Rel-17 HST enhancement, Apple

[18] R1-2006600, Enhancements on HST-SFN deployment, LG Electronics

[19] R1-2006722, Discussion on HST-SFN deployment, NTT DOCOMO, INC.

[20] R1-2006794, Enhancements on HST-SFN deployment, Qualcomm Incorporated

[21] R1-2006847, Enhancements for HST-SFN deployment, Nokia, Nokia Shanghai Bell