**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.

|  |
| --- |
| 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 2-1: Ds=700m, Dmin=150m  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   + 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. |
| Huawei, HiSilicon | If I remember correctly, we have Alt.2-1 for FR2 before. Some companies support such cases. Why it is only Alt.2-3 and Alt.2-4? We prefer Alt.2-1.  Then, as we explained that Alt.2-4 is mainly introduced for tunnel cases with Dmin=5m, Samsung’s example is for tunnel-like deployment, but in our thinking for the deployment is much more distance for the Dmin. So, we are not fine with Alt.2-4 with Dmin=5. |
| vivo | Support Option 1. Dmin=5 is considered for tunnel deployment, which might be not a typical deployment for outdoors. |
| CMCC | Alt 2-1: Ds=700m, Dmin=150m is preferred. As companies explained, Alt.2-4 is mainly for tunnel scenario, we think it is very challenge for many countries and operators to have such kind of deployment for outdoor scenario. |
| Ericsson | Support Option 1. It would be difficult to provide a good beam coverage with option 2. We are fine with Option 3 also. |
| Futurewei | Option 1, and second preference Option 3 |
| QC | We support Option 1 (Alt 2-3 from Table 1). As highlighted in our previous response, we think option 2 is not well suited for beam management with such small Dmin. If Dmin=5m is to be used, Ds should be much smaller. |
| FL | Summary:   * Option 1 – 10 companies * Option 2 – 2 companies * Option 3 – 1, +2 (as a 2nd preference) companies   **Updated FL proposal:**   * Alt 2-3 is mandatory, other alternatives, i.e. Alt 2-4 and Alt. 2-1, are optional. |

## 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

|  |  |
| --- | --- |
| 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. |
| Huawei, HiSilicon | At least 20m should be supported for outdoor deployment. 5m is not preferred. |
| vivo | Support 20m. |
| CMCC | 20 is more applicable for real outdoor deployment scenario. |
| Ericsson | We support 10m. The RRH height can be dependent on the choice of 2.2.1. |
| Futurewei | Support 20m. The RRH needs to have a sufficient height to cover a few hundred meters, but it is not likely to be as high as a macro tower. |
| QC | We support 5-10m. agree with Ericson that the selection of the RRH height is tied to the HST layout especially Dmin. |
| FL | Summary:   * 5m – 4 companies * 10m – 4 companies * 15m – 1 company * 20m – 6 companies * 35m – 1 company * It was noted that TRP height is dependent on the HST layout.   **Updated FL proposal:**   * For Alt 2-1 in Table 1 - TRP height is 35m * For Alt 2-3 in Table 1 - TRP height is 20m * For Alt 2-4 in Table 1 - TRP height is 5m   Note from FL:  35 meters for Alt 2-1 was selected to align with FR1 assumptions  20 meters for Alt 2-3 was selected based on majority preference  5m meters for Alt 2-4 was selected since this alternative is closer to 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

|  |  |
| --- | --- |
| 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. |
| Huawei, HiSilicon | Support FL’ proposal. Please note that 8-ports are already deployed in current rail way scenarios. |
| vivo | Support 8 ports, which has been deployed in practical network. |
| CMCC | Support.  8-port is indeed deployed in our HST-SFN 5G network. Both 2-port and 8-port are used for different scenarios from our point of view. If companies have burden to simulate with 8-port, 2-port can be used. If companies have more simulation resources, 8-port can be additionally provided. |
| Ericsson | We are fine with adding 8 ports to FR1 evaluation, but suggest to remove “as mandatory configuration” from the proposal, i.e.,  **Proposal:**   * Include 8 ports at TRP for FR1 evaluations. |
| Futurewei | Support |
| QC | Support proposal. |
| FL | Summary:   * Mandatory – 6 * Optional/Not needed – 8   **Updated FL proposal:**   * Support 8 antenna ports as optional configuration |
|  |  |
|  |  |

## 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

|  |  |
| --- | --- |
| 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. |
| Huawei, HiSilicon | Support Option-1. |
| vivo | Support Option 2. |
| CMCC | Support Option-1. I have to say, the antenna radiation pattern in table 3 and table 4 are the real patterns for 2Tx and 8Tx used in our current HST-SFN 5G network, and many companies have already produced their products based on this. I also agree Samsung’s argument, then I think Table 5 can be used for other cases except 2Tx and 8Tx.  Maybe the following proposal can be a compromise:   * Table 3 for 2Tx and Table 4 for 8Tx * Table 5 for other #Tx |
| Ericsson | Option 1 for FR1, Option 2 for FR2,  with a change of 8Tx configuration in table 4 from  8Tx: [Mg, Ng, M, N, P]=[1, 1, 1, 4, 2],  To  8Tx: [Mg, Ng, M, N, P]=[1, 1, 2, 2, 2]  Otherwise, the 3dB gain reduction from table 3 doesn’t seem make sense. |
| Futurewei | Option 1 |
| QC | We are fine with the radiation pattern of option 1 for FR1, however, the per-element antenna gain seems higher than expected 5-6dBi for a typical patch antenna used in most of the BST array. We would like CMCC to comment on the assumed antenna type that has 17.5-20.5 dBi.  Another point we want to clarify, for the 2ports layout in FR1 the antenna pattern is fixed while for 8 ports it is scannable.  Also, we support option 2 (Table 5) for FR2. |
| FL | Summary:   * Option 1 – 4, +2 (FR1 only), +1 (2Tx only) * Option 2 – 5, +2 (FR2 only) * Option 3 – 1   **Updated FL proposal:**   * FR2 – Table 5 * FR1 – 2Tx – Table 3, 8Tx – Table 4, other #Tx – Table 5   Continue discussion on antenna model for FR1.   * Antenna configuration in Option 1 for 8 ports (Table 4) is [1, 1, 1, 4, 2], which is not aligned with antenna configuration for 8 ports in Table 1, which is [1, 1, 2, 2, 2] * Double check antenna gains in Option 1 (see question from Ericsson and QC) |
| CMCC | Regarding Ericsson’s question, I think you noticed that the value of the horizontal half power width for each Tx of 2Tx is 33 degree, while the value of the horizontal half power width for each Tx of 8Tx is 65 degree, that’s the reason why there is 3dB gap for the maximum directional gain of an antenna element between 2Tx and 8Tx. We further explained below.  Actually, for 8Tx [Mg, Ng, M, N, P]=[1, 1, 1, 4, 2], each Tx here consists of 8~12 typical antenna elements in one column using fixed connection (the typical antenna element here refers to the antenna element in table 5 whose maximum directional gain is modelled as 8dBi. In reality, the actual value may vary between 6~8dB. You can see that, if we assume each Tx here consists of 10 typical antenna elements, then the gain of each typical antenna element will be 7.5dB, which is close to 8dBi in table 5).  For 2Tx [Mg, Ng, M, N, P]=[1, 1, 1, 1, 2], each Tx here consists of 16~24 typical antenna elements in two columns with 8~12 in each column using fixed connection.  Regarding QC’s first concern, I’m not sure if the typical patch antenna is similar to the antenna element in table 5. If it is not, I will doubt the value of 5~6dBi. Maybe more explanation can be provided by QC.  Regarding QC’s second point, i.e., antenna pattern of 8 ports is scannable, I think you mean the antenna pattern formed by 8 ports is determined based on the weight of the 4 ports with the same polarization, right? If Yes, I confirm that.  So, the 8Tx should remain [Mg, Ng, M, N, P]=[1, 1, 1, 4, 2], i.e., in a single row. |
|  |  |

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 directional 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 |
| Huawei, HiSilicon | OK |
| vivo | Support |
| CMCC | OK |
| Futurewei | Support |
| QC | Support UE direction antenna model in Table 6 for FR2. |
| FL | **FL proposal:**   * Adopt directional antenna model in Table 6 based on TR 38.802 |

## 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 TRPs
  + 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 |
| Huawei, HiSilicon | Prefer Alt.1, but can accept Option 2. |
| vivo | Support Option 2. |
| CMCC | Prefer Alt.1 (Alt.1 is more practical), we can accept Option 2 for compromise. |
| Ericsson | Support Option 2. |
| Futurewei | Option 1 |
| QC | Support option 2. |
| FL | **FL proposal:**   * Antenna downtilt and azimuth directions point to the midpoint between the two TRPs |

## 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. |
| Huawei, HiSilicon | We also concern for the modelling here. In RAN1 we have not used and modelled the CFO. The similar understanding with InterDigital, we do not think it is needed. |
| vivo | We support perfect synchronization as basic simulation assumption. Also, we are fine that companies provide details for TRP/UE CFO error and TRP timing errors additionally. |
| CMCC | Same view as InterDigital. It is very hard for companies to align the modelling since it may vary in different deployment scenarios. |
| Ericsson | Agree with proposal. In addition, TR 38.101-2 can be considered for UE in FR2. The gain from pre-compensation schemes is highly dependent on the accuracy of estimations and the RF impairment, we should take error factors into account for the pre-compensation schemes. |
| Futurewei | Agree with InterDigital |
| QC | Support the proposal.  We strongly encourage companies to consider the time/frequency synchronization between the TRPs and the UE specifically the CFO errors at least for Doppler shift pre-compensation schemes. One suggested method to model the CFO is to assume a uniform distribution between [-ppm ppm]\*fc (Hz) for each simulation point which will capture the temporal variation. |
|  | Some companies think that synchronization errors are important to consider while other companies not important. For study phase it is not good to preclude companies to consider such type of practical impairments. On the other hand, there is no consensus to recommend these models for evaluation.  **Updated FL proposal:**   * Perfect synchronization as baseline * 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 may be optionally considered   + Additional details are provided by each company   + Consider already available models in TR 38.101-1/2 and TR 38.104 |

## 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. |
| vivo | Prefer SNR values to be reported by companies. |
| CMCC | Support |
| Ericsson | For a given Tx power, the SNR is different at different UE locations along the track. If we force the SNR to the same at all locations, it doesn’t reflect the reality. For example, at certain location, the UE may never achieve 30dB SNR.  To use a UE position closest to a RRH as reference seems reasonable, as QC proposed in previous discussions, i.e., the SNR for other positions is scaled based on the channel model (i.e., distance to the RRHs) and the reference point SNR. For each SNR value at the reference point, a simulation is run for UE at all positions along the track. And multiple SNR values can be simulated. |
| Futurewei | Support |
| QC | We support the proposal and we suggest adding the note and figure below to the proposal to unify the understanding of SNR modelling across the companies even if companies elect to report their own SNR values. As Ericson pointed out, the SNR will vary across the different locations based on the distance at the track as the TRPs has fixed Tx Power.  Note: SNR is at reference point where UE is closest to the TRP. The SNR at other track points is scaled based on the channel mode. |
| FL | Summary   * Pre-determined SNR – 7 companies * Up to each company – 5 companies   **Updated FL proposal**   * It is recommended to provide results for SNR = 8, 12, 16, 20 dB * Other SNR values are not precluded   For further discussion SNR definition:   * SNR is defined at actual UE position * SNR is defined relative to the reference point (closest to RRH) |

## 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 |
| vivo | Don’t support Option 2. It can’t show the performance differences when UE is located at different positions along the railway. |
| CMCC | Option 1 is preferred |
| Ericsson | A combination of option 2 and 3 is preferred. Option 3 with a few points at specific location, e.g, mid track point, close to RRH, plus Option 2 with average throughput. |
| Futurewei | Option 1 |
| QC | We suggest adopting option 1 for at least few points in the track with different SNR values. |
| FL | Summary:  It seems Option 2 is not acceptable to several companies and has least support.  **Updated FL proposal:**   * The results should be reported   + Option 1: Per track location (at specific SNR)   + Option 3: Throughput vs SNR at specific location (e.g. mid track point).   Please provide your views whether additional details should be agreed, such as specific track positions in Option 3 |

## 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

|  |  |
| --- | --- |
| 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. |
| vivo | We think the simulation assumption is enough to cover the mentioned types of UE, such as CPE setup on the roof and UEs inside the train. |
| CMCC | Not necessary |
| Ericsson | We suggest considering both CPE and headsets inside the train. |
| Futurewei | Up to the companies |
| QC | In our views channel models and UE types are related. As both 4 taps channel model and the extended CDL channel models are supported, they cover both UE types. |
| FL | It seems majority of the companies believes that the current set of the channel models is sufficient to model different types of UEs |

## CDL based channel model as mandatory

It was proposed to make CDL based channel model as mandatory. Companies are encouraged to provide views on this proposal.

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

# 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 (1st priority)

Several companies vivo, ZTE, Interdigital, Sony, Futurewei, CATT, Intel, Lenovo/Motorola Mobility, OPPO, Samsung, CMCC, Spreadtrum, Huawei / HiSilicon, Ericsson, Apple, LGE, NTT DOCOMO, Qualcomm, Nokia/Nokia Shanghai Bell (22) propose enhancements for DL transmission in HST-SFN deployment scenario using UE based solutions. For the discussion purpose it is proposed to categorize the proposed schemes as follows:

**Proposal #1**

For the discussion purpose consider the following categorization of the enhanced DL transmission schemes

* **Scheme 1**:
  + TRS is transmitted in TRP-specific manner
  + DM-RS and PDCCH/PDSCH from TRPs are transmitted in SFN manner
* **Scheme 2**:
  + TRS and DM-RS are transmitted in TRP-specific manner
  + PDSCH from TRPs is transmitted in SFN manner

|  |  |
| --- | --- |
| Company | Comment |
| OPPO | Fine with the proposal. |
|  |  |
|  |  |
|  |  |
|  |  |

Based on the company’s contributions, it is proposed to study the following aspects related to support of the corresponding schemes.

**Proposal #2**

Study the following aspects of the enhanced transmission schemes:

* **For scheme 1**:
  + Target DL physical channels, i.e. PDSCH or PDSCH + PDCCH
  + The maximum number of N (N>1) of QCL/TCI states that should be supported for indication
  + L1/L2 signaling details for indication of multiple QCL/TCI states for DM-RS antenna port(s)
  + Necessity of indication of SFN transmission for differentiation with Rel-16 non-SFNed transmission schemes with multiple QCL/TCI states
  + Link-level performance comparison with the baseline scheme
  + Note: Other aspects are not precluded
* **For scheme 2**:
  + Association of MIMO layer of PDSCH to DM-RS antenna ports
  + L1/L2 signaling details for indication of multiple QCL/TCI states for the DM-RS antenna ports of PDSCH
  + The maximum number of N (N>1) of QCL/TCI states that should be supported for indication
  + Link-level performance comparison with the baseline scheme
  + Note: Other aspects are not precluded

Companies are encouraged to provide their views regarding key aspects that should be considered by companies in the future meetings.

|  |  |
| --- | --- |
| Company | Comment |
| OPPO | * For 2nd sub-bullet of scheme 1, we think N=2 as in Rel-16 can be assumed based on contributions from companies. The necessity to support cooperation of more than 2 TRPs is unclear. * For 3nd sub-bullet of scheme 1, Rel-16 already supports indication of two TCI states for the same DMRS ports. We don’t think any enhancement is needed specifically for indication of TCI states. * For 4nd sub-bullet of scheme 1, UE needs to differentiate the new scheme from Rel-16 schemes, so we propose to impose on the signalling design instead of the necessity. * For 5nd sub-bullet of scheme 1, comparison with scheme 2 is also needed for down selection. * For 2nd sub-bullet of scheme 2, Rel-16 already supports indication of two TCI states for different CDM groups. We don’t think any enhancement is needed specifically for indication of TCI states. * For 3rd sub-bullet of scheme 2, we think N=2 can be assumed based on contributions from companies. * For 4nd sub-bullet of scheme 2, comparison with scheme 1 is also needed.   So our proposal is:   * **For scheme 1**:   + Target DL physical channels, i.e. PDSCH or PDSCH + PDCCH   + Whether more than 2 QCL/TCI states are supported and corresponding signaling ~~The maximum number of N (N>1) of QCL/TCI states that should be supported for indication~~   + ~~L1/L2 signaling details for indication of multiple QCL/TCI states for DM-RS antenna port(s)~~   + ~~Necessity of~~ Whether and how to indicate ~~indication of~~ SFN transmission for differentiation with Rel-16 non-SFNed transmission schemes with multiple QCL/TCI states   + Link-level performance comparison with the baseline scheme and scheme 2   + Note: Other aspects are not precluded * **For scheme 2**:   + Association of MIMO layer of PDSCH to DM-RS antenna ports   + Whether more than 2 QCL/TCI states are supported and corresponding signaling ~~L1/L2 signaling details for indication of multiple QCL/TCI states for the DM-RS antenna ports of PDSCH~~   + ~~The maximum number of N (N>1) of QCL/TCI states that should be supported for indication~~   + Link-level performance comparison with the baseline scheme and scheme 1   + Note: Other aspects are not precluded |
|  |  |
|  |  |
|  |  |
|  |  |

## NW based solutions (1st priority)

Several companies CMCC, QC, ZTE, CATT, OPPO, CMCC, Spreadtrum, Huawei / HiSilicon, Apple, Qualcomm, Nokia/Nokia Shanghai Bell (13) propose enhancements for DL transmission in HST-SFN deployment scenario using NW based solutions, which in high-level includes 3 main steps as shown in Figure 1.



Figure 1 High level procedure of TRP-based frequency offset pre-compensation

**Proposal #1:**

For discussion purpose consider the following three steps for TRP-based frequency offset pre-compensation scheme:

* **1st step**: Transmission of the 1st set of TRS resource(s) from TRPs without pre-compensation
* **2nd step**: Transmission of the uplink signal(s) with carrier frequency determined based on the received TRS signals in the 1st step
* **3rd step**: Transmission of the 2nd set of TRS resource(s) from TRPs with frequency offset pre-compensation determined based on the received signal in the 2nd step

Based on the company’s contributions, it is proposed to study the following aspects related to support of the corresponding scheme.

**Proposal #2:**

Study TRP-based frequency offset pre-compensation including the following aspects:

* Aspects related to indication of the carrier frequency determined based on the received 1st set of TRS resource(s) in the 1st step
  + **Option 1**: Implicit indication using uplink signal(s) transmitted on the carrier frequency acquired in the 1st step
    - Signaling for QCL-like association of the 1st set of TRS 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 information acquired in the 1st step using CSI framework
    - CSI reporting aspects, configuration, quantization, signalling details, etc.
* New QCL types/assumption for TRS with other RS (e.g., SS/PBCH), when the 2nd set of TRS resource(s) is used as target RS in TCI state
* New QCL types/assumptions for TRS with other RD (e.g., DM-RS), when 2nd set of TRS resource(s) is used as source RS in the TCI state
* Target physical channels (e.g., PDSCH or PDSCH/PDCCH) and reference signals that should be supported for pre-compensation
* Feasibility of group-specific transmission of 2nd set of TRS resources
* Note: Other aspects are not precluded

|  |  |
| --- | --- |
| Company | Comment |
| OPPO | For proposal 1, we think UE-specific pre-compensation on TRS needs significant TRS overhead, and is not a method proposed by many companies. In 3rd step, the pre-compensation on PDSCH/DMRS is more important than TRS. In our opinion, pre-compensation on TRS doesn’t help much for channel estimation. The necessity of two sets of TRS and UE-specific pre-compensation on TRS is unclear. So our proposal is to consider the following steps for discussion:   * **1st step**: Transmission of ~~the 1~~~~st~~ ~~set of~~ TRS resource(s) from TRPs without pre-compensation * **2nd step**: Transmission of the uplink signal(s) with carrier frequency determined based on the received TRS signals in the 1st step * **3rd step**: Transmission of PDSCH/DMRS ~~the 2~~~~nd~~ ~~set of TRS resource(s)~~ from TRPs with frequency offset pre-compensation determined based on the received signal in the 2nd step   For proposal 2, we suggest the following wording for some bullets:   * New QCL types/assumption for TRS with other RS (e.g., SS/PBCH), when the ~~2~~~~nd~~ ~~set of~~ TRS resource(s) is used as target RS in TCI state * New QCL types/assumptions for TRS with other ~~RD~~RS (e.g., DM-RS), when ~~2~~~~nd~~ ~~set of~~ TRS resource(s) is used as source RS in the TCI state * Target physical channels (e.g., PDSCH or PDSCH/PDCCH) and reference signals that should be supported for pre-compensation * Whether multiple sets of TRS and pre-compensation on TRS is needed * ~~Feasibility of group-specific transmission of 2~~~~nd~~ ~~set of TRS resources~~ |
|  |  |
|  |  |
|  |  |
|  |  |

## Other enhancements (2nd priority)

Some companies have proposed enhancement that could not be categorized as part of enhancements provided in Section 3.1 and 3.2. It is, therefore, proposed to study additional enhancements separately.

**Proposal #3:**

* Study the following enhancements:
  + Clustering of QCL, TCI and CSI
  + Zone-based resource pooling
  + Enhanced QCL configuration to indicate relative polarity of Doppler shift
  + Signaling of the beam transition information
  + Enhancements related to DM-RS
* Interested companies are encouraged to provide additional details to facilitate evaluation of the above schemes

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

# Other issues

This section contains other issues the companies want to highlight.

|  |  |
| --- | --- |
| Company | Comment |
| FL | RRHs will be replaced with TRP to align terminology |
|  |  |
|  |  |

# 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