**3GPP TSG RAN WG1 #102-e R1-2006127**

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

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary for multi-beam enhancement

**Document for:** Discussion and Decision

1. Introduction

In this summary, the term “item 1” refers to the first item in the Rel.17 NR FeMIMO WID, i.e. multi-beam enhancement:

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| --- |
| 1. Enhancement on multi-beam operation, mainly targeting FR2 while also applicable to FR1:    1. Identify and specify features to facilitate more efficient (lower latency and overhead) DL/UL beam management to support higher intra- and L1/L2-centric inter-cell mobility and/or a larger number of configured TCI states:       1. Common beam for data and control transmission/reception for DL and UL, especially for intra-band CA       2. Unified TCI framework for DL and UL beam indication       3. Enhancement on signaling mechanisms for the above features to improve latency and efficiency with more usage of dynamic control signaling (as opposed to RRC)    2. Identify and specify features to facilitate UL beam selection for UEs equipped with multiple panels, considering UL coverage loss mitigation due to MPE, based on UL beam indication with the unified TCI framework for UL fast panel selection |

This summary includes the Phase-2 EVM summary for item 1 and the additional EVM-related issues raised in the submitted contributions after the Phase-2 EVM offline discussion was concluded. Moderator proposals are made to conclude the EVM issue for the item 1 of Rel.17 FeMIMO.

1. Phase-2 item-1 EVM summary and proposals

An initial proposal and inputs from participating companies are collected in Appendix B. From the discussion, the moderator recommends that the following proposals pertaining to item-1 EVM be **agreed**.

**Proposal 1:** SLS is the baseline tool for evaluation.

* Two separate SLS EVMs are used for: 1) intra-cell mobility scenarios, 2) MPE mitigation (UL coverage loss due to meeting MPE regulation) and multi-panel UE
* Note**:** Baseline is interpreted as follows: when simulation is needed and/or justified, the agreed baseline constitutes the required minimum to be simulated
  + This does not preclude companies from providing additional simulation results with other set(s) of assumptions (e.g. # panels, traffic models, deployment scenarios) and/or types (e.g. LLS)

**Proposal 2:** The simulation assumptions are given below. Items that are the same as what has been agreed in Rel.16 are in green

Table 1 Baseline assumptions for SLS: common for intra-cell mobility and MPE/MP-UE

|  |  |
| --- | --- |
| **Parameters** | **Values** |
| Frequency Range | FR2 @ 30 GHz,   * SCS: 120 kHz * BW: 80 MHz |
| Transmission Power | Maximum Power and Maximum EIRP for base station and UE as given by corresponding scenario in 38.802 (Table A.2.1-1 and Table A.2.1-2) |
| BS Antenna Configuration | (M, N, P, Mg, Ng) = (4, 8, 2, 2, 2). (dV, dH) = (0.5, 0.5) λ. (dg,V, dg,H) = (2.0, 4.0) λ  Companies to explain TXRU weights mapping.  Companies to explain beam selection.  Companies to explain number of BS beams |
| BS Antenna radiation pattern | TR 38.802 Table A.2.1-6, Table A.2.1-7 |
| UE Antenna Configuration | Number/location of panels: 3 panels (left, right, and back)  Panel structure: 1x4x2 or (M, N, P) = (1, 4, 2), dH = 0.5 λ  Companies to explain TXRU weights mapping.  Companies to explain beam and panel selection.  Companies to explain number of UE beams |
| UE Antenna radiation pattern | TR 38.802 Table A.2.1-8, Table A.2.1-10 |
| Beam correspondence | Companies to explain beam correspondence assumptions (in accordance to the two types agreed in RAN4) |
| Link adaptation | Based on CSI-RS |
| Traffic Model | Full buffer |
| Inter-panel calibration for UE | Ideal, non-ideal following 38.802 (optional) – Explain any errors |
| Control and RS overhead | Companies report details of the assumptions |
| Control channel decoding | Ideal or Non-ideal (Companies explain how it is modelled) |
| UE receiver type | MMSE-IRC as the baseline, other advanced receiver is not precluded |
| BF scheme | Companies explain what scheme is used |
| Transmission scheme | Multi-antenna port transmission schemes  Note: Companies explain details of the using transmission scheme. |
| Other simulation assumptions | Companies to explain serving TRP selection  Companies to explain scheduling algorithm |
| Algorithm details (when applicable) | Companies to report:   * Beam reporting mechanism * Beam metric L1-RSRP * Number of active panels |
| Other potential impairments | Not modelled (assumed ideal).  If impairments are included, companies will report the details of the assumed impairments |

Table 2 Baseline assumptions for SLS: Intra-cell mobility scenarios

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| --- | --- |
| **Parameters** | **Values** |
| Scenarios | High speed @FR2:   * Dense Urban (macro-layer only, TR 38.913) @FR2, 200m ISD, 2-tier model with wrap-around (7 sites, 3 sectors/cells per site), 100% outdoor   + One UE is dropped for each of the 21 sectors/cells (see mobility description below) * High speed train (TR 38.802/38.913) @FR2   + One UE is dropped for one cell (see mobility description below) |
| UE Speed | For Dense Urban: 60 km/hr and 120 km/hr  For HST: 256 km/hr |
| UE Mobility and trajectory handling | Linear trajectory, intra-cell mobility (constrained within one cell)   * Trajectory sampling at most spaced by decorrelation distance   Dense Urban:    For each of the 21 cells: One UE is are dropped as follows:  There are four possible starting locations P, Q, R, and S as illustrated above for the upper right sector/cell (can be extended analogously to the upper left and lower sectors/cells, see Appendix B) where d=30m and x=4m.  There are two possible randomly selected trajectory lines for the dropped UE:   * Tr1: A UE starts at P and moves along the 120-deg line downward to Q * Tr2: A UE starts at R and moves along the 120-deg line upward to S   HST (based on TS38.802/913):    The origin (0,0) is assumed to be at RRH2 and between the 2 tracks   * Only one UE is simulated (representing one CPE in the train) * Distance between two adjacent RRHs is drrh = 200 m * Distance between the tracks is dtrack = 6 m * Distance between RRH and nearest track is drrh\_track = 5 m * RRH has a bearing angle or where =20 degrees * The UE starts near RRH2 and moves towards RRH5, or starts near RRH5 and moves towards RRH2 * Possible starting points are near , , , * There are two possible randomly selected travel directions for the UE, each with two possible starting locations (a total of four trajectories):   + Direction 1: The UE starts near RRH2 (at either P or S) and moves on a horizontal line to the right   + Direction 2: The UE starts near RRH5 (at either R or Q) and moves on a horizontal line to the left |
| UE and panel orientation | Companies will describe the assumed UE and panel orientation relative to the direction of the trajectory |
| Performance metrics | * CDF of UE throughput, avg. and 5% UE throughput, cf. Appendix B * TCI state update (beam indication) signaling overhead (separate analysis from SLS) * Beam switching latency * RSRP distribution |

Table 3 Baseline assumptions for SLS: MPE/Multi-panel UE

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| --- | --- |
| **Parameters** | **Values** |
| Scenarios | * Dense urban (macro-layer only, TR 38.913) @FR2, 200m ISD, 2-tier model with wrap-around (7 sites, 3 sectors/cells per cell), 100% outdoor   + Companies explain the number of dropped UEs * Indoor (TR 38.901/802) |
| UE speed | 3 km/hr for indoor UEs, 30km/hr for outdoor UEs |
| Panel Blockage Modeling for MPE | Only one panel is blocked. The blocked panel is randomly selected at each drop   * Blocking entails an additional pathloss of 10dB applied to both DL and UL   For simulation with full buffer traffic, a blocking event is determined, started at the beginning of each drop, and sustained throughout the entire drop. |
| MPE Modeling | When MPE occurs, the maximum TX power for the covered panel is reduced by 10dB P-MPR. That is, the actual maximum TX transmit power = maximum UE TX power (23dBm) – P-MPR (10dB) |
| UE-side panel switching latency | 0 ms for active panels  Companies explain the assumed switching latency for inactive panels |
| UE and panel orientation | Vertical but random in azimuth |
| UE dropping | Random, companies will state the assumed number of dropped UEs per cell |
| Performance metrics | * CDF of UE throughput, avg. and 5% UE throughput (representing cell-edge coverage), cf. Appendix B * RSRP distribution |

**Table 4 Baseline assumptions for SLS: Additional simulation assumptions for HST scenario (FR2), mainly from TR 38.802, e.g. Table A.2.1-2**

|  |  |
| --- | --- |
| **Parameters** | **Values** |
| Carrier Frequency | 30 GHz |
| Scenario | UMa LOS |
| System BW | 80 MHz |
| BS and RRH Tx Power | 30 dBm, max EIRP 69 dBm |
| Maximum UE Tx Power | 21 dBm, max EIRP 43 dBm |
| BS receiver Noise Figure | 7 dB |
| UE receiver Noise Figure | 13 dB |
| Distance between cell and nearest lane | 5m |
| Inter site distance | 200m |
| BS Antenna height | 2.5m |
| UE Antenna height | 1.5 m |
| Train penetration Loss | 38.901, sec 7.4.3.2: μ = 9 dB, σp = 5 dB |
| RRH and cell association | For intra-cell mobility simulation, all RRHs are assumed to be associated with one cell (for simplicity) |

**Table 5 Baseline assumptions for SLS: Additional simulation assumptions for Dense Urban scenario (FR2) mainly from TR 38.802 Table A.2.1-1, and TR 38.901.**

|  |  |
| --- | --- |
| **Parameters** | **Values** |
| Carrier Frequency | 30 GHz |
| Scenario | UMa LOS |
| System BW | 80 MHz |
| BS Tx Power | 40 dBm |
| Maximum UE Tx Power | 23 dBm |
| BS receiver Noise Figure | 7 dB |
| UE receiver Noise Figure | 10 dB |
| Inter site distance | 200m |
| BS Antenna height | 25m |
| UE Antenna height | 1.5 m |
| Car penetration Loss | 38.901, sec 7.4.3.2: μ = 9 dB, σp = 5 dB |

1. Official email discussion focusing on inter-cell mobility EVM

Focusing on the following possible moderator proposal, companies are asked to share their views.

**Possible proposal 3**: Further discuss and decide in RAN1#102-e between the following two baseline EVM alternatives for inter-cell mobility:

* Alt1. The SLS-based EVM for intra-cell mobility is extended to inter-cell mobility with the trajectory and one-UE drop illustrated in Figure 1
  + The baseline Rel.15/16 L3-based inter-cell mobility is modeled as follows: [...]
* Alt2. No baseline EVM for inter-cell mobility



Figure 1

(Copied from Table 7 summarizing offline discussion during preparation phase)

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Issue** | **Companies** | **Moderator proposal** |
| 1 | Inter-cell mobility EVM  Alt 1. Same as intra-cell (SLS) but with different latency model for Rel.15/16 baseline  Alt 2. None | Alt 1: ZTE, Samsung, Huawei/HiSi, Apple, Intel (L3 HO needs more discussion)  Alt 2: vivo, Ericsson, MediaTek, IDC, LGE | Since the same design will be used for intra- and inter-cell mobility, designing a scheme for inter-cell from conclusions derived from intra-cell alone may be unwarranted. More discussion seems needed. |

Table 6 Inputs from companies on possible proposal 3

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| **Company** | **View** |
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Appendix A: clarification on EVM

Linear trajectory for Dense Urban (used for intra-cell mobility evaluation): To avoid potential ambiguity, an example is given in the following diagram. Here, the UE is dropped in each of the three cells associated with one site. The diagram is used for describing the travel directions. The following characteristics should be observed when implementing the Dense Urban model for mobility evaluation:

* The linear trajectories are parallel to the nearest outer edge of the associated cell. Therefore, as d=30m, the maximum length of the two linear trajectories (to ensure the UEs are always inside the associated cells) are and meters, respectively.
* With the 7-site 21-sector/cell model, there will be a total of 21x1=21 UEs



UE throughput for Full Buffer traffic: To derive the CDF, UE throughout statistics are collected across K UEs (K=total number of UEs across all the 21 cells) and M drops. The UE throughout for UE-k and drop-d TP(k,d) is calculated from the total number of bits successfully decoded by UE-k on drop-d divided by the time duration of drop-d (in sec). Then the CDF of UE throughput can be derived from the KD UE throughput values { TP(k,d), k=1,2, ..., K, d=1,2, ..., D }. Note that the value of K is 2x21=42 for Dense Urban and 1 for HST.

Appendix B: Compilation of companies’ views during phase 2 offline

Based on the companies’ inputs in Phase 1 discussion, an initial proposal on baseline EVM assumptions needed for Rel.17 item 1 beyond Rel.16 EVM is given below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Note:** The content of this section pertains to the proposed baseline assumption where baseline is interpreted as follows:   * When simulation is needed and/or justified, the agreed baseline constitutes the required minimum to be simulated * This does not preclude companies from providing additional simulation results with other set(s) of assumptions, e.g. to strengthen their arguments   **Proposal 1:** When it is needed and/or justified, SLS is the baseline tool for evaluation. Examples include (but not limited to):   * Evaluating enhancements for high mobility scenarios, at least for intra-cell mobility * Evaluating UL coverage loss mitigation due to MPE regulation   **Proposal 2:** When SLS is needed and/or justified, the simulation assumptions are given in the table below. Items that are the same as what has been agreed in Rel.16 are in green.  Baseline assumptions for SLS   |  |  | | --- | --- | | **Parameters** | **Values** | | Frequency Range | FR2 @ 30 GHz,   * SCS: 120 kHz * BW: 80 MHz | | Scenarios | Dense urban (TR 38.901/38.913)  High speed @FR2:   * Highway (Urban Macro, TR 38.901/37.885) @FR2 * High speed train (TR 38.802/38.913) @FR2 | | UE Speed | 60 km/hr (for outdoor UEs, Dense Urban)  120 km/hr (for outdoor UEs, Dense Urban)  256 km/hr (only for HST @FR2) note: 160mph per operator’s input | | Transmission Power | Maximum Power and Maximum EIRP for base station and UE as given by corresponding scenario in 38.802 (Table A.2.1-1 and Table A.2.1-2) | | BS Antenna Configuration | (M, N, P, Mg, Ng) = (4, 8, 2, 2, 2). (dV, dH) = (0.5, 0.5) λ. (dg,V, dg,H) = (2.0, 4.0) λ  Companies to explain TXRU weights mapping.  Companies to explain beam selection.  Companies to explain number of BS beams | | BS Antenna radiation pattern | TR 38.802 Table A.2.1-6, Table A.2.1-7 | | UE Antenna Configuration | **Number/location of Panels**   * 3 Panel UEs (left, right and back)   **Panel structure**   * 1x4x2 (Baseline) * Other panel structures optional (company to report)   Companies to explain TXRU weights mapping.  Companies to explain beam and panel selection.  Companies to explain number of UE beams | | UE Antenna radiation pattern | TR 38.802 Table A.2.1-8, Table A.2.1-10 | | Beam correspondence | Companies to explain beam correspondence assumptions (in accordance to the two types agreed in RAN4) | | Link adaptation | Based on CSI-RS | | Traffic Model | FTP model 1 with packet size 0.5Mbytes (other value is not precluded).  Other traffic models including the full buffer are not precluded. | | Inter-cell mobility related | Companies to explain cell association scheme | | Panel Blockage Modeling | Need discussion | | MPE Modeling | Need discussion  e.g. Maximum power (EPIR) per beam direction/panel | | UE-side panel switching latency | Need discussion | | UE Mobility, trajectory handling and UE rotation | Need discussion  e.g. Mobility with linear trajectories;  Companies to provide details on add-on features including UE mobility, rotation, blockage, spatial consistency etc. | | Inter-panel calibration for UE | Ideal, non-ideal following 38.802 (optional) – Explain any errors | | Control and RS overhead | Companies report details of the assumptions | | Control channel decoding | Ideal or Non-ideal (Companies explain how it is modelled) | | UE receiver type | MMSE-IRC as the baseline, other advanced receiver is not precluded | | BF scheme | Companies explain what scheme is used | | Transmission scheme | Multi-antenna port transmission schemes  Note: Companies explain details of the using transmission scheme. | | Other simulation assumptions | Companies to explain serving TRP selection  Companies to explain scheduling algorithm | | Algorithm details (when applicable) | Companies to report:   * Beam reporting mechanism * Beam metric L1-RSRP; L1-SINR is optional * Number of active panels | | Performance metrics (when applicable) | * Outage * CDF of UPT, avg. and 5% UPT * Overhead * Latency of beam switching * Latency of Handover | |

Companies are encouraged to share their views *especially* on the yellow highlighted rows.

Based on the inputs gathered in below, the above will be refined accordingly to arrive at a final proposal.

Inputs from companies on the content of the above initial proposal

|  |  |
| --- | --- |
| **Company** | **Input** |
| Ericsson | SLS for mobility:   * It is unlikely that classical SLS (i.e., UTP) for mobility would lead to comparable results * The mobility setup is still unproven: although there is a channel model in place, the procedure to handle users that cross cell borders is unclear * There are far too many free parameters, e.g., beam management and scheduling. The simulations on L1-SINR in Rel-16 resulted in a wide range of differing results, due to unclear selections on other parameters – it is highly likely that the same thing will happen again. * A highly simplified setup is proposed which may lead to comparable results:   + Straight line mobility – all positions must be in the same cell   + Each mobility trace is 40m   + Ideal beam selection at the UE   + Single user in a cell, full buffer traffic   SLS for coverage loss mitigation due to MPE regulation:   * *Max EIRP for the UE:* 22dBm (PC3) * *Panel blocking model:* additional pathloss of 10dB for one random panel for every UE * *MPE modeling:* max transmit power for covered panel reduced by 10dB when more than 15% of the scheduled symbols during 1s are uplink symbols (RAN4). * *UE-side panel switching latency:* 0ms (all panels can be used for measurements simultaneously, but only one can be used for transmission) |
| InterDigital | * To save time, it would be better to simplify SLS development by splitting the evaluation assumptions with two separate focus of inter-cell mobility evaluation and MPE regulations. * For example, we could assume a fixed MCS for inter-cell mobility evaluation, while a CSI-RS-based link adaptation could be a better choice for MPE studies. * The HST scenario (256 Km/h) may be dropped to avoid overlapping studies with the HST sub-agenda. * Besides considering handover latency, handover failure and RLF events may also need to be counted. Also, the time associated for beam/link recovery can be considered. * For blockage modeling, the models in 38.901 may be used, however a single set of assumptions for temporal variability of the model should be agreed among companies. * For panel blockage modeling (hand gripping), it would be sufficient to agree on a set of potential loss values and occurrence probabilities. |
| DOCOMO | For multi-panel UE, take 2 panels per UE as baseline, and 3 or 4 panel UE as optional. The same antenna configuration per panel is baseline.  For multi-panel UE, a single panel can be selected by UE for UL TX based on UL BM. UE-side panel switching latency is 0 ms. |
| Samsung | **SLS Simulation Use Cases:**  For high speed train/highway scenarios as well as scenarios with MPE events, comparing various options.  **UE Mobility (HST/Highway):**   * For HST, [6] TRPs with wrap around. TRPs alternate on either side of the track. Distance between cell and nearest track/lane is 5 m. Distance between two tracks is 6m. Single RRH at each TRP site. Each 3 TRPs make up one cell. * For Highway, linear model (36.885 Figure A.1.3-2) with [2] cells with wrap around. Cells are on one side of the road. Distance between cell site and nearest lane is 35m. Distance between cells is 1732 m. [6] lane road, [3] lanes in either direction, with 4-meter lane width. * UE moving at uniform speed along the road. * Inter-cell (and Inter-TRP if applicable) handover modeled.   **gNB/UE beams for HST/Highway:**   * 16 gNB beams: 8 Azimuths [-7/16pi -5/16p -3/16pi -1/16pi 1/16pi 3/16pi 5/16pi 7/16pi] x 2 Elevation [1/4pi 3/4pi] * 8 UE beams: 4 Azimuths [-3/8pi -1/8pi 1/8pi 3/8pi] x 2 Elevation [1/4pi 3/4pi] * For other scenarios, company reports.   **Performance Metrics:**   * CDF of UPT, avg. and 5% UPT * Control channel overhead (can also be calculated analytically).   **Scenarios:**  Dense urban (TR 38.901/38.~~913~~ 802)   * 2 tier (7 sites with 21 cells)   **UE speed for MPE:**  No high mobility, (i.e. 3kmp for indoor UEs, and 30 kmph for outdoor UEs, cf. 38.901)  **BS Antenna Configuration for MPE:**  (M, N, P, Mg, Ng) = (16, 8, 2, 1, 1)  **Panel Blocking Model:**  We agree with Ericsson, that one panel out of the 3 UE panels is randomly selected to be blocked. A blocked panel incurs an additional [10] dB pathloss. When a panel is blocked, it is blocked for M [=100] consecutive slots before a panel is randomly selected for blockage.  **MPE modeling:**  Blocked panel is impacted by MPE event. MPE event reduces the maximum transmitted power by [10] dB.  **Traffic Model:**  FTP model 1 with packet size 0.5Mbytes for DL and 0.1Mbytes for UL  **Transmission scheme**:  CB based, rank 1 only  **Performance Metrics for MPE:**   * CDF of UPT, avg. and 5% UPT * Latency of beam/panel switching   **UE side panel switching delay:**   * 1 slot   **Update on 21-Jul-20: Inputs for V17\_interim**  **Regarding Inter-cell mobility**  Objective 1a includes: “higher intra- and L1/L2-centric inter-cell mobility”. Therefore, we suggest that Table 4a is added for intercell mobility as follows:  “Table 4a: Baseline assumptions for SLS: Inter-cell mobility scenarios”   |  |  | | --- | --- | | **Parameters** | **Values** | | Scenarios | High speed @FR2:   * Highway (Urban Macro, TR 38.901/37.885) @FR2, 200m ISD * High speed train (TR 38.802/38.913) @FR2 | | UE Speed | For Highway (Urban Macro), all UEs are outdoor   * 60 km/hr * 120 km/hr   For HST, 256 km/hr | | UE Mobility, trajectory handling and UE rotation | Linear trajectory, inter-cell mobility (trajectory can cross cell boundaries) | | Performance metrics | * CDF of UPT, avg. and 5% UPT * TCI state update (beam indication) signaling overhead * Beam switching latency |   Additional simulation assumptions for HST scenario, mainly from TR 38.802, e.g. Table A.2.1-2. FR1 scenario can be optional and FR2 is baseline.   |  |  |  | | --- | --- | --- | | **Parameter** | **FR1 Optional** | **FR2** | | Carrier Frequency | 4 GHz | 30 GHz | | Scenario | RMa LOS | UMa LOS | | System BW | 40 MHz | 80 MHz | | BS Tx Power | 49 dBm | 30 dBm, max EIRP [69] dBm | | UE Tx Power | 23 dBm | 21 dBm, max EIRP [43] dBm | | BS receiver Noise Figure | 5 dB | 7 dB | | UE receiver Noise Figure | 9 dB | 13 dB | | Distance between cell and nearest lane | 5 m | [5] m | | Inter site distance | 1732m | 200m | | BS Antenna height | 35m | [2.5]m | | UE Antenna height | 1.5 m | | | UE Speed | 256 km/h | | | Train penetration Loss | 38.901, sec 7.4.3.2: μ = 9 dB, σp = 5 dB | |   Additional simulation assumptions for highway scenario, mainly from TR 37.885 Table 6.1.1-2, and Table 6.1.4-1 and TR 36.885. FR1 scenario can be optional and FR2 is baseline.   |  |  |  | | --- | --- | --- | | **Parameter** | **FR1 Optional** | **FR2** | | Carrier Frequency | 4 GHz | 30 GHz | | Scenario | RMa LOS | UMa LOS | | System BW | 40 MHz | 80 MHz | | BS Tx Power | 49 dBm | 43 dBm, max EIRP [78] dBm | | UE Tx Power | 23 dBm | 23 dBm, max EIRP [43] dBm | | BS receiver Noise Figure | 5 dB | 7 dB | | UE receiver Noise Figure | 9 dB | 13 dB | | Highway Lanes | 6x4m, 3 lanes per direction | | | Distance between cell and nearest lane | [35] m | [35] m | | Inter site distance | 1732m | 200m | | BS Antenna height | 35m | 25m | | UE Antenna height | 1.5 m | | | UE Speed | 60 km/h and 120 km/h | | | Car penetration Loss | 38.901, sec 7.4.3.2: μ = 9 dB, σp = 5 dB | |   **Regarding the traffic model**  We **suggest to change FTP 3 to FTP 1** due to the following reasons.  (a) The simulation time for FTP3 usually is more than FTP1. For FR2 with beam sweeping, it can be too large. Also, there is no tangible benefit in insight with FTP3 over FTP1.  (b) In Rel. 16, FTP1 was agreed as baseline (cf. email discussion [94b-NR-09]). There is no reason why it needs to be changed in R17.  (c) 3 companies want (or are fine with) FTP1 as baseline. 5 companies want FTP 3 as baseline, with one of these companies OK for FTP1 to be optional.  Supporting companies for FTP1 and FTP3:  FTP model 1. Supported by Samsung, CATT, Vivo.  Optional: Qualcomm  FTP model 3. Supported by ZTE, Qualcomm, Intel, Apple, FutureWei.  (d) For UL SLS, the use of FTP3 is not reasonable since the packet size is expected to be small (e.g. 0.1Mbytes).  **Update on 28-Jul-20: Inputs for V25\_interim5**  We propose the following model for the trajectory of a HST scenario    The origin (0,0) is assumed to be at RRH2 and between the 2 tracks   * Distance between two adjacent RRHs is drrh = 200 m * Distance between the tracks is dtrack = 6 m * Distance between RRH and nearest track is drrh\_track = 5 m * RRH has a bearing angle or . Companies to report value * All RRHs belong to the same cell * UEs start near RRH2 and move towards RRH5, or start near RRH5 and move towards RRH2 * Possible starting points are near , , , * There are two possible randomly selected trajectory lines for each of the UE1 and UE2:   + Tr1: A UE starts near RRH2  (at either P or S) and moves on a horizontal line to the right   + Tr2: A UE starts near RRH5  (at either R or Q) and moves on a horizontal  line to the left * The two trajectories are selected such that UE1 and UE2 do not collide |
| ZTE | In general, we have two different aspects (e.g., mobility and MPE that are decoupled) to be evaluated, and consequently we need to consider the specific EVMs which are dedicated to each of them. It seems that the current drafted SLS EVM is much likely for mobility rather than MPE.  **Comment-1:** Regarding Proposal-1, instead of evaluating coverage loss, it is recommended to evaluate the potential enhancement through the fast UE panel switching that seems to be much aligned with WID. Consequently, the bullet of “UL coverage loss mitigation due to MPE regulation” in proposal-1 should be replaced by “Evaluating UL coverage enhancement through fast UE panel switching due to MPE regulation”.  Also LLS should be considered for evaluating fast UE panel switching or DL simultaneous reception across UE multi-panel (for 2c, where we do not have separate discussion).  ***Proposed changes (in red):***  **Proposal 1:** When it is needed and/or justified, SLS is the baseline tool for evaluation. Examples include (but not limited to):   * Evaluating enhancements for high mobility scenarios, at least for intra-cell mobility * Evaluating UL coverage enhancement through fast UE panel switching ~~loss mitigation~~ due to MPE regulation * Note that LLS is another candidate tool for evaluation, e.g., evaluating fast UE panel switching, or DL simultaneous reception across UE multi-panels in 2c.   **Comment-2:** Regarding scenarios,   * Indoor hotspot should be further added, especially for evaluating MPE issues (Example 2 in Proposal-1), where the UE mobility is not serious. Also indoor hotspot is assumed as an important and typical scenario for FR2 deployment. * Regarding Dense urban, the single-layer (Macro layer, ISD~200m) in TS 38.802 is recommended as first priority. Also there are two candidate mix of O2I penetration loss models for higher carrier frequency as follows, and we prefer to use the Option-1 or only consider outside UE as an initial assessment/ITU evaluation.  |  | | --- | | - Option1  - Low loss model – 80%  - High-loss model – 20%  - Option2  - Low loss model – 50%  - High-loss model – 50% |  * Regarding High speed, ISD in Urban Macro in TS 38.901 is 500m that is too much for FR2 considering DL/UL coverage (according to evaluation results, like MIMO calibration/ITU). Alternatively, ISD = 200 m as an example is recommended. Indoor UT ratio is recommended as 0% rather than 80%.   + The evaluation in High speed train (TR 38.802/38.913) @FR2 is unclear for us. Some further clarification is need. For instance, for layout, do we only need to consider Macro + relay nodes (Dedicated linear deployment along railway line)? If so, we do not need to evaluate the communication link between relay and UEs, in our views. If Macro only, the simulation complexity should be fully considered due to that the number of users per train is up to 1000. * In general, indoor hotspot (e.g., 3 km/h) and dense urban with high UE speed (e.g., 60/120 km/h) are prioritized.   ***Proposed changes (in red):***   |  |  | | --- | --- | | Scenarios | Indoor hotspot (TR 38.901)  Dense urban (TR 38.901/38.913)   * single-layer (Macro layer, ISD~200m) * Option-1 for O2I penetration loss; or all outdoor UEs   High speed @FR2:   * Highway (Urban Macro, TR 38.901/37.885) @FR2   + ISD = 200 m is recommended   + Indoor UT ratio is 0% * High speed train (TR 38.802/38.913) @FR2   + Layout and number of UEs, etc., should be further clarified. |   **Comment-3:** Regarding UE Antenna Configuration,   * As we evaluated in Rel-15/16, 2 and 4 panels should be considered also besides 3 panels. * Regarding panel structure, we also prefer (M, N, P) = (2, 4, 2) for the case of 2 UE panels.   ***Proposed changes (in red):***   |  |  | | --- | --- | | UE Antenna Configuration | **Number/location of Panels**   * 2 Panel UEs(left, right) * 3 Panel UEs (left, right and back) * 4 Panel UEs(left, right, back and front)   **Panel structure**   * 2x4x2 (Baseline for 2 Panel UEs) * 1x4x2 (Baseline for 3/4 Panel UEs) * Other panel structures optional (company to report)   Companies to explain TXRU weights mapping.  Companies to explain beam and panel selection.  Companies to explain number of UE beams |   **Comment-4:** Regarding Traffic Model, the each of UE(s) is only to transmit one packet in mode-1 (per-cell traffic), which means that we can hardly evaluate the handover/mobility case within the single packet. Alternatively, the traffic mode 3 (per UE traffic) is recommended that packets for the same UE arrive according to a Poisson process. A large packet side, e.g., 50Mbytes, can be considered for evaluating handover/mobility and a much real traffic in 2020. Besides, full buffer is preferred for evaluating UPT for fast UE panel switching.  ***Proposed changes (in red):***   |  |  | | --- | --- | | Traffic Model | FTP model ~~1~~ 3 with packet size 0.5Mbytes / 50Mbytes (other value is not precluded).  Other traffic models including the full buffer are not precluded. |   **Comment-5:** Regarding MPE Modeling, this model should be further studied. From our perspective, the requirement for beam-specific EIRP is recommended as a baseline.  ***Proposed changes (in red):***   |  |  | | --- | --- | | MPE Modeling | Beam specific EIRP requirement as a baseline |   **Comment-6:** Regarding UE-side panel switching latency, panel switching to an inactive panel takes [2~3] ms followed by RAN4 LS (R4-1808542). If the panel is active, the latency can be assumed as 0 ms.  ***Proposed changes (in red):***   |  |  | | --- | --- | | UE-side panel switching latency | From inactive to active: 3ms,  From active to active: 0 ms. |   **Comment-7:** Regarding UE Mobility, trajectory handling and UE rotation, we support the moderator’s suggestions.  ***Proposed changes (in red):***   |  |  | | --- | --- | | UE Mobility, trajectory handling and UE rotation | Mobility with linear trajectories;  Companies to provide details on add-on features including UE mobility, rotation, blockage, spatial consistency etc. |   **Comment-8:** Regarding outage, it can be defined that a UE is in outage if residual BLER after HARQ retransmissions (up to 3) exceeds 1%.   * If the latency is evaluated together, we can assume the following case as in outage that maximum latency of data transmission is more than 10 ms.   **Comment-9:** The definition for latency for beam and handover switching should be clarified clearly, according to our knowledge that we do not have any previous RAN1-led EVMs or evaluation methods for both of them.  **Update on 24-Jul-20: Inputs for V19\_interim**  **Comment-1:** Considering the scope of this WID, we share the same views with Samsung that inter-cell mobility at least should have the same priority with intra-cell mobility.   * We still need to further review the tables of HST/high-way EVMs as proposed in the V19\_interim2. But, after quick review, personally speaking, I think that we may need to simplify this SLS EVM. For instance, we can directly use UMa/dense-urban scenario and evaluate a UE with random linear trajectory for high-speed mobility, rather than further simulating the layout of "Highway Lanes (3 lanes per direction) and HST railway". Simulation complexity should be carefully considered. * Besides, in terms of performance metrics, handover latency and outage should be considered. We slightly prefer to remove “TCI state update (beam indication) signaling overhead” which can hardly be evaluated in the SLS, to be honest J.   ***Proposed changes (in red):***   |  |  | | --- | --- | | Performance metrics | * CDF of UPT, avg. and 5% UPT * Outage * Handover latency * ~~TCI state update (beam indication) signaling overhead~~ * Beam switching latency |   **Comment-2:** Regarding Traffic Model, the each of UE(s) is only to transmit one packet in mode-1 (per-cell traffic), which means that we can hardly evaluate the handover/mobility case within the single packet. It is hard for us to imagine the huge large of packets for evaluating about 10 s (10GB?) (e.g., from one cell to another cell). Also, if we really want to find a huge big of packets, full buffer can be used directly.  In our views, this model-1 is suitable for a normal drop based SLS rather than a mobility with trajectory. Alternatively, the traffic mode 3 (per UE traffic) is still recommended that packets for the same UE arrive according to a Poisson process.  Considering inter-cell mobility, a packet size of 50 Mbytes are recommended as an optional.  ***Proposed changes (in red):***   |  |  | | --- | --- | | Traffic Model | FTP model ~~1~~ 3 with packet size 0.5Mbytes / 50Mbytes (other value is not precluded).  Other traffic models including the full buffer are not precluded. |   **Comment-3:** Since 2 panels (left, right) is adopted in this version, the corresponding antenna elements should be updated as in TS 38.802, i.e., 2x4x2 rather than 1x4x2 (a typo?)  ***Proposed changes (in red):***   |  |  | | --- | --- | | UE Antenna Configuration | Number/location of panels: 2 panels (left, right)  Panel structure: 2~~1~~x4x2  Companies to explain TXRU weights mapping.  Companies to explain beam and panel selection.  Companies to explain number of UE beams |   **Comment-4:** MPE impact is based on the accumulative value of exposure rather than an instantaneous one. So, in our views, this panel blockage should be last for a long time, e.g., ~100s or more (like a telephone calling or playing a game). So the panel blockage should be drop based, and we can provide a reasonable probability for a UE with MPE, e.g., 20% or 100% (for the UE with already existing MPE impacts)  ***Proposed changes (in red):***   |  |  | | --- | --- | | Panel Blockage Modeling for MPE | Only one panel is randomly blocked   * Drop based * 100% UE with panel blockage as baseline (20% UE as optional) * Blocking entails an additional pathloss of 10dB * ~~Each blocking event lasts for 100 slots~~ | |
| Huawei/Hisi | Scenarios   * The definition of ‘Highway’ scenario referring to 38.901 is unclear. It seems to refer to UMa with relatively high moving speed for outdoor users, if it is correct understanding. * The system-level evaluation assumptions for ‘High speed train’ scenario defined in 38.802 has adopted simplified CDL/TDL channel models with fixed angular parameters. Some clarifications/alignment for High speed train scenario description based on 38.802 are needed in RAN1.   UE Speed   * Referring to ‘Dense urban’, shall RAN1 assume that 80% indoor users and 20% outdoor users following 38.901? 20% outdoor users may not lead to meaningful results for mobility evaluation so that we suggest changing to 100% outdoor or 80% outdoor + 20% indoor.   UE Antenna Configuration   * Regarding UE panel placement, simply saying ‘left, right and back’ may not be specific enough. We suggest describing the facing directions of UE panels (such as 0, 90, and 180 degrees for the 1st/2nd/3rd panel, in relative to UE orientation, for the case with 3 panels), similar as Config 1/2 in Table A.2.1-4 in 38.802. * Regarding the number of UE panels, we suggest including 4 panels as an optional configuration, with facing directions of 0, 90, 180, and 270 degrees (in relative to UE orientation), which similar as Config 2 in Table A.2.1-4 in 38.802.   Inter-cell mobility related   * While exact cell association scheme may be left to companies to report, it can be beneficial and important to disclose certain details, such as performance metrics (e.g., RSRP), threshold values (e.g., -80dB), UE beam selection criteria (e.g., wide beam or narrow beam), service degradations experienced/assumed during HO execution (e.g. 100ms of interruption), etc.   Panel Blockage Modeling   * It can be difficult to define/agree with very detailed model of panel blockage. Our suggestion is to apply a simplified model with [10]dB UL Tx power dropping due to panel blockage with a probability of [0.3] over each UE panel independently. The duration of blockage per panel can last for [50]ms (to stimulate the duration of blockage event, in a time scale that is comparable with the total simulation duration).   MPE Modeling   * It can be too ideal to assume that for a given panel or beam, the radio emission can be estimated perfectly and handled (to meet MPE regulation) without any latency. The MPE senor may not be perfect and also needs certain processing time. We suggest optionally considering [20]% of mis-detection and [10]ms estimation/processing delay.   UE-side panel switching latency   * Panel selection at UE side cannot be perfect in Rel-15/16 with zero switching delay. As the baseline of mimicking UE autonomous panel selection, we may assume that UE autonomously switches to the “best” panel with the highest RSRP every [240]ms (12 rounds of SSB measurement opportunities with 20ms SSB periodicity), for simplicity. * If there is explicit indication from NW in Rel-17 (if agreed) demanding UE to awaken/switch to an inactive panel from an existing active panel, a processing/preparation delay of [5]ms is required for that inactive panel.   UE Mobility, trajectory handling and UE rotation   * Linear trajectory seems reasonable to evaluate mobility performance in SLS. However one aspect that needs to be discussed in RAN1 is whether/how to model spatial consistency along each trajectory line when using stochastic channel models. The complexity of SLS simulators may need to be taken into account, with certain simplifications as a trade-off. * While linear trajectory confined within each cell seems to be reasonable for evaluating intra-cell mobility, it may not be able to stimulate inter-cell mobility with which cross-cell trajectories would be needed. As the baseline of mimicking UE autonomous panel selection, we may assume that UE switches to the best panel with the highest RSRP every [240]ms (12 rounds of SSB measurement opportunities with 20ms SSB periodicity), for simplicity.   Other simulation assumptions   * To have comparable results for latency/overhead reduction among companies, we suggest aligning on assumed latency/overhead for different signalling methods, for simplification, for example latency/overhead per RRC/MAC-CE message are assumed as 20/4(ms) and 2000/20(bytes), respectively.   Additional aspects   * As intra-band CA is listed in the WID, when evaluating signaling/RS overhead, we suggest assuming 4 DL CCs and 2 UL CCs as a reference. * When evaluating mobility performance, as it impacts the required number of RRC reconfigurations and MAC-CE activations directly, actual UE capability/limitation are critical (e.g., how many beam measurement RS that UE can be configured with, how many active TCI state UE can track, whether UE supports R16 features). To be closer with existing commercial UE implementations, we suggest assuming that the UEs can be configured with 8 periodic beam measurement RS and 1 active TCI state for PDCCH/PDSCH (minimum UE capability in R15), and additionally support R16 features on latency/overhead reduction (so to evaluate gains over R16). If it is difficult to reach consensus in RAN1, we suggest asking companies to report the assumed UE capabilities with regarding to # of RS configurations and active TCI state(s), if applicable. |
| Qualcomm | For Scenarios  • Consider slow mobility model like UMI as baseline at least for MPE  For UE speed  • Consider 3km/h as baseline at least for MPE  Traffic model  • Consider FTP model 3 as baseline, which is also used in other WI/SI  • FTP model 1 and full buffer can be optional  MPE modeling  • Additional loss [10] dB due to blocking for one random panel in both DL & UL  • Plus: reduction of max transmit power by [10] dB for the blocked panel  • For UE max EIRP, fixed 22 dBm can be considered  UE side panel switching latency  • 0ms if panel switching is already known by UE  UE mobility  • Consider UE rotation as baseline at least for MPE  Inter-panel calibration for UE  • Ideal  UE receiver  • MMSE-IRC  Algorithm details  • L1-RSRP based beam selection  • 1 active panel at any time as baseline  Performance metrics  • CDF of UPT, avg. and 5% UPT  • Throughput in case of full buffer |
| OPPO | Evaluation Scenarios:   * Including the HST scenario here seems to have overlapping with item 2d.   UE Antenna Configuration:   * Suggest to include UE with 2 panels. * UE with 2 panels is the baseline.   Panel blockage model:   * For a UE with N panels, the probability of one panel being blocked is [X%]. * The blockage of each panel is generated independently. The duration of blockage of one panel is randomly selected between [Y1，Y2] ms.   MPE Modeling:   * RAN4 have agreed to use MAC CE to report a MPR (maximal power reduction) per UE. That mechanism shall be used as the baseline scheme for evaluation. However, how to determine MPR is not specified but left for UE implementation. * It is hard to specify maximum EPRI per Tx beam. Because that would depend on UE hardware capability critically. What is the angle/beamwidth resolution that the UE can detect and then determine the power backoff? What is the latency for the UE to determine that? To meet the MPE requirement, the UE can either transmit with a lower power and longer time duration or transmit with a higher power and shorter time duration. Thus UEs could choose different power backoff values for the same situation. * Suggest to use power backoff [10] dB on one Tx panel as the starting point.   UE-side panel switch latency:   * 0ms latency is not proper because that means all the panels are always turned on. * The switch latency is a SCS-independent value. * [3] ms can be the starting pointing.   UE Mobility, trajectory handling and UE rotation:   * UE mobility with linear trajectory. |
| Lenovo/MotM | **Multi-panel related:**  Regarding the UE panel assumption:   * For UE panel assumption, we think the orientation of each panel should be aligned to get comparable results, and the configuration defined in Table A.2.1-4 in 38.802 can be taken as a baseline.   Regarding the MPE modeling:   * We think 2 panel UE is mandatory. Three and four panel should be optional. N is the number of panels below. * We agree with Ericsson and Samsung that one panel out of N panels is randomly selected to be blocked and additional [10] dB pathloss is added to the blocked panel. So, [10] dB maximum transmission power reduction can be introduced for MPE event. The duration of blockage of a panel can last [100] slots.   Regarding the panel switching delay:   * We should first clarify how an activated panel can be used, for example, all activated panel can be used for DL reception but only one of them can be selected for UL transmission. So, two delay values should be defined, one is for active a panel and another is for select a panel. * The guard period defined for antenna switching in Table 6.2.1.2-1 in TS38.214 can be a baseline for panel selection/switching. * 3ms suggested by RAN4 in R4-1808542 can be used as the latency for panel activation.   Regarding transmission scheme   * Codebook based rank 1 PUSCH transmission should be the baseline.   **Inter-cell mobility related**  Baseline configuration   * There are so many free parameters, e.g. the number of periodic CSI-RS resources for beam management and the corresponding periodicity, the number of activated TCI-states for PDCCH and PDSCH, the L1-RSRP threshold for handover, can lead to very different simulation results. * So, we suggest a baseline detail configurations at least including the following assumptions should be made to get comparable results. * The number of CSI-RS resources and CSI reporting settings for beam management, and the minimal periodicity for periodic L1-RSRP reporting; * The L1-RSRP threshold for handover. * The periodicity of periodic CSI-RS for RLM periodicity of CSI-RS for mobility. * The number of activated TCI-states for PDCCH and PDSCH.   For mobility model:   * We support Samsung’s HST/highway model for mobility   Performance metrics:   * The handover latency including the number of RRC reconfigurations and MAC-CE activations can be taken as performance metrics. |
| LG | **Antenna configuration**  As Rel-15/16, the existing number of panels, i.e. 2 and 4, should be considered in addition to 3 panels. In our perspective, 2-panel configuration is assumed as a baseline for multi-panel. Note that the existing 2 (and 4) panel antenna modeling is considered as a homogeneous antenna panel type. This assumption often cannot reflect practical UE implementations that the space for antenna is quite limited and those spaces would not be of same size depending on its form factor. Hence, for multi-panel modeling, we also consider heterogeneous antenna array configuration on 2-panel model as baseline as well.  **Panel blockage modeling**  For a blocked panel, it seems reasonable to randomly choose the panel with same probability as Ericsson proposed.  **UE-side panel switching latency**  0ms as a baseline by assuming that all panels are already active and utilized for the purpose of UL beam measurement. We may optionally consider panel switching delay larger than 0ms when awaking inactive panel. Further details of the latter case need to be clarified, e.g. performance metric.  **UE mobility, trajectory handling and UE rotation**  Straight-line trajectory seems a reasonable assumption to evaluate UE mobility. While considering the spatial consistency along the trajectory would evaluate the UE mobility performance practically, it also causes a high complexity on SLS. Hence, it needs a further discussion for a simplified setup. |
| Intel | **UE Mobility Evaluations (SLS):**   * **Motivation:** Given the main motivation is the evaluation of beam management performance (latency/tracking/overhead) under mobility, it is our understanding that key performance metrics and baseline evaluation assumptions should be carefully defined. As Ericsson pointed out, having multiple free parameters and overly complex evaluation methodology may lead to widely diverging results. To this end, we suggest the following. * **Performance Metrics:** To identify the major bottlenecks in beam management under mobility, performance of beam tracking should be evaluated as the UE moves along a trajectory. To this end, we suggest   + As a baseline, the L1-RSRP should be used.   + Optionally UPT can be considered with full buffer and FTP Model 3. Simply looking at UPT might not give a good indication of major performance bottlenecks, therefore we prefer instead to evaluate tracking performance using L1-RSRP over the UE trajectory. * **Scenario:** Our preference is to concentrate more on beam management performance evaluations. As a baseline, we suggest   + Dense Urban Micro   + Single layer with [100/200] m inter-cell radius.   + Single high-speed UE in a single cell. UE is assumed to be outdoor.   + Optionally, HST deployment scenario can also be considered. Detailed SLS deployment and simulation assumptions including channel models should be further clarified.   + Optionally, multi-cell with handover modeling can also be considered * **UE Trajectory:** Straight line UE trajectory within the deployment. Optionally RAN2 methodology for handover evaluations in 36.839 Figure 5.4.5.1.2 can be considered (assuming only macro-cells) * **Impairment modeling:**    + SSB/CSI-RS based beam tracking at UE and gNB with realistic latency modeling for signaling and tracking   + UE with single active panel at a time and no panel switching latency   Additionally, to limit excessive free parameters and results variability across companies, the following should be further clarified and ideally fixed before evaluations:   * Spatial Consistency Model A vs. B (for LSP and SSP).   + In our view, Model B is more suited to a trajectory-based evaluation approach and should be used as a baseline * Blockage model * UE rotation model * UE/BS Antenna configuration and number of TCI states (or analog beams) * If UPT is used as performance metric, interference modeling should be clarified e.g., whether random beams from other cells are used for interference calculation. * If handover is used, modeling should be clarified   **Multi-Panel MPE Evaluations (SLS):**   * Baseline 2 panel UE. Additionally, 3/4 panels can be considered * Single active panel for UL transmission * Same view as Ericsson i.e., additional 10dB loss for randomly selected covered panel * No panel switching latency. All UE panels can be used for measurement and best panel selected for transmission * L1-RSRP should be baseline metric and optionally UPT for full-buffer can also be considered. * Multi-TRP deployment for evaluation of MPE should also be considered with same priority as single-TRP. |
| Apple | Scenario   * Indoor should be included for MPE evaluation, in addition to Dense Urban Macro   UE speed   * 3km/h should be included with regard to MPE related evaluation   UE antenna configuration   * Suggest clearly defining the bearing angle and down-tilt angle for each panel, especially the 3rd panel, to avoid potential misunderstanding   Traffic model   * We recommend full buffer and FTP model 3   UE panel switching delay   * 2 or 3ms could be used for evaluation purpose   UE mobility   * We think rotation is more important and we can define some candidate rotation speed, e.g. 360/720 degree per second   Transmission scheme   * For UL, codebook based transmission scheme should be baseline |
| CATT | UE antenna configuration:   * Suggest to use 2 panels as baseline; 3/4 panels may be additionally evaluated.   Panel Blockage Modeling   * Random selection of one (or a set of) UL panels for blockage; if more than one UL panels are blocked, independent blockage on each panel; * Panel blockage: either a fixed value (e.g.10dB) or a random value (e.g. Gaussian distribution of 10dB mean)   UE-side panel switching latency   * 0ms as baseline;   UE mobility, trajectory handling and UE rotation:   * Include 3 km/hr (in addition to 60, 120, 256km/hr in Table 2) – it is also interesting to evaluate pedestrian users performance. * Straight line movement.   Traffic model:   * Fine with FTP model 1. Full-buffer can be optional. |
| vivo | Evaluation for mobility   * SLS can be used to evaluate the performance for the case of inter-cell beam management, considering UE rotation and blockage. * For UE mobility with linear trajectories, LLS can be used to simplify simulation, like HST in multi-TRP case, with additional modification to mimic UE movement as following,   + the large scale fading caused by distance varies as the UE moves, with a specific transmit SNR determined at a reference position   + UE performs beam management along the trajectory   Evaluation for MPE   * Scenario:   + UMI, UE speed=3km/h   + High speed@FR2 is not necessary * UE Antenna Configuration:   + Suggest 2/4 panel UEs * Panel Blockage Modeling for MPE:   + UE is attached to a cell with the best one UE panel assuming no blockage.   + Randomly select one UE panel as the blocked panel with certain probability   + Additional 10dB loss on blocked panel * MPE modeling:   + For FTP model 1, the blocked UE panel is not changed during the transmission of entire FTP package.   + Based on RAN4 discussion, maximum EIRP for the UE is 22dBm (PC3), maximum safe EIRP is 12dBm to comply with major RF EMF exposure standards when uplink duty cycle=100%. With other duty cycles, the maximum safe EIRP is scaled accordingly.   + Companies to report the uplink duty cycle. |
| MediaTek | Agree with Proposal 1.  On Proposal 2, we also prefer to separate SLS EVMs for evaluating high mobility and MPE issues. Some views on simulation assumptions are listed as follows:   1. **SLS for coverage loss mitigation due to MPE regulation**  * Scenarios: Both dense urban and indoor hotspot should be considered * UE speed: 3km/h for indoor UEs and 30 km/h for outdoor UEs * UE antenna configuration   + Number of equipped panels: 3 (left, right, back) is baseline. Other number is optional (companies to report).   + Panel structure: (M, N, P) = (1, 4, 2) with (dv, dh) = (0.5, 0.5) is baseline. Other panel structure is optional (companies to report).   + Panel direction: 0, 90, and 180 degrees for the 1st/2nd/3rd panels in relative to UE orientation   + Panel position: Companies to report the panel positions in relative to each other * Modeling of panel blockage and MPE: A simple modeling is sufficient. For every UE, one panel is randomly selected as the blocked panel out of the equipped panels for a duration [X] slots, and there is always one blocked panel.   + The blocked panel has an additional [Y] dB pathloss   + Maximum transmit power on the blocked panel has to be reduced by [Z] dB, where [Z] is defined by RAN4 according to UL duty cycle. * UE-side panel switching latency: No switching latency. One panel is selected and activated out of the equipped panels for UL transmission * UL transmission scheme: Codebook based transmission is baseline  1. **SLS for high mobility**  * UE trajectory: Straight line UE trajectory within the deployment is baseline * Spatial consistency: Spatial consistency procedure defined in TR 38.901 is baseline * Companies to provide details on add-on features including rotation and blockage |
| Futurewei | UE antenna panel   * 2 panels with homogeneous configuration as baseline, 3 and 4 panels with heterogeneous configurations as optional * All panels are assumed to be available for beam measurement, 2 panels are assumed to be active for DL reception and one panel is assumed to be used for UL transmission * Switching time for activated panel is 0ms and for inactivated panel is [3ms] * Each panel is independently blocked with certain probability and with a fixed duration [X]ms. Assuming 10dB loss when blocked * For detected MPE panel, additional [Y] dB TX power backoff depending on the UL duty cycle. The maximum EIRP is fixed 22dBm for all beam   Traffic model   * Since the evaluation is targeting the performance of beam management under high mobility and fast panel switch, full buffer and FTP model 3 are more appropriate to show the performance difference between different schemes   Evaluation scenarios   * For HST/highway evaluation, support Samsung’s model with UE straight-line trajectory with consideration on spatial consistency along the trajectory * For MPE consider low mobility 3km/h   Beam related parameters   * We agree that many parameters could have big impact on performance, so it’s better to agree on the fixed set of these parameters, e.g. periodicity of CSI-RS for beam measurement and reporting, PDCCH and PDSCH activated states etc. * Other beam assumptions may also greatly affect beam switching complexity and latency, e.g. whether common beam can be assumed need to be clarified |
| Nokia/NSB | Transmission Power  *Maximum Power and Maximum EIRP for base station and UE as given by corresponding scenario in 38.802 (Table A.2.1-1 and Table A.2.1-2)*   * We want to propose as baseline EIRP of 32 dBm (max PA power of 23 dBm + 1x4 array gain of 9 dB including an implementation loss of 3 dB). The amount of implementation loss could be increased to a higher number (for example 5 or 6 dB), if that is more realistic.   UE Antenna Configuration  ***Number/location of Panels***   * *3 Panel UEs (left, right and back)* * Other panel configuration could be discussed to model UE’s with different coverage capabilities.   ***Panel structure***   * *1x4x2 (Baseline)* * *Other panel structures optional (company to report)* * *Different panel structure on the same UE should also be considered as an option.*   *Companies to explain TXRU weights mapping.*  *Companies to explain beam and panel selection.*  *Companies to explain number of UE beams*   * For a 1x4 panel we see 5-7 beams with around 22.5° 3dB beam width each, to cover an angular space between 90° to 120°.   Panel Blockage Modeling  We consider here human body impact, since more general blockage is handled in channel model. In this respect we should look at directional blockage where beam toward/from certain direction is blocked regardless of the panel.  MPE modeling  There are a few P-MPR characteristics as follows:   * P-MPR static or dynamic: we prefer static model (dynamic FFS depending on proximity sensors of the UE) * P-MPR value: as it depends on EIRP, we suggest P-MPR of 20 dB aligned with EIRP of 32 dBm. * P-MPR modeling x% of the time.   UE-side panel switching latency   * In principle we would like to strive for zero latency, but we admit that it depends on the active panels for downlink and uplink.   UE mobility, trajectory handling and UE rotation   * UE can arbitrarily use wide beams with lower gain or narrow beams with higher gain, we suggest UE behavior with wide beams for mobility robustness, e.g. inter-cell mobility and with narrow beams for intra-cell mobility, hence two separate evaluations. * SS bursts monitoring are associated with wide beams on the UE (UE doesn’t not know where the power is coming from, hence wide beams) * Discuss scheduling of aperiodic CSI-RS with repetition ‘on’ to enhance UE narrow beam tracking.’ * UE rotation could be more challenging than UE trajectory and speed, so a model for UE rotation should be considered. |

Some further discussions occurred for the following topics.

The baseline number of UE panels: The following companies have provided some inputs (including offline inputs to the moderator) in regard to the moderator proposal of 3 (as of 07/27/2020):

* At least the following 14 companies have expressed that the proposed baseline number (3 panels) is either preferred or acceptable: Apple, CATT, Huawei/HiSi, Intel, Ericsson, Mediatek, Nokia/NSB, OPPO, Qualcomm, Samsung, vivo, ZTE
  + It is argued that this represents one of the most common and relevant UE antenna architecture for FR2.
* Two companies have expressed that a baseline of 2 panels should also be added (in addition to 3) and have not revised their view: LG, NTT Docomo
  + It is argued that this is one of the assumptions in Rel.16 eMIMO EVM and therefore should be reused.

This leads the moderator to propose 3 panels as the baseline value.

P-MPR: The following companies have shared their views on P-MPR modeling.

|  |  |
| --- | --- |
| **P-MPR** | **Companies** |
| Alt1 (7dB) | Ericsson, CATT |
| Alt2 (10dB) | ZTE, Apple, Ericsson, Mediatek, Sony, Samsung, Qualcomm, Huawei/HiSi |
| Alt3 (14dB) | Apple, ZTE, Sony, Qualcomm |
| Alt4 (randomly selected from {4, 7, 10} dB) | vivo, CATT |

This leads the moderator to propose P-MPR = 10dB

Appendix C: Summary and compilation of companies’ views after contribution submission (preparation phase)

Based on the final outcome of the Phase-2 EVM discussion, some additional issues were raised in the submitted contributions ([1]-[26]) along with additional inputs captured in **Table 8** as summarized below:

**Table 7 Summary of EVM issues raised in contributions**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Issue** | **Companies** | **Moderator proposal** |
| 1 | Inter-cell mobility EVM  Alt 1. Same as intra-cell (SLS) but with different latency model for Rel.15/16 baseline  Alt 2. None | Alt 1: ZTE, Samsung, Huawei/HiSi, Apple, Intel (L3 HO needs more discussion)  Alt 2: vivo, Ericsson, MediaTek, IDC, LGE | Since the same design will be used for intra- and inter-cell mobility, designing a scheme for inter-cell from conclusions derived from intra-cell alone may be unwarranted. More discussion seems needed. |
| 2 | UE dropping:   * Intra-cell mobility SLS: change # UEs per cell from 2 to 1 * MPE: random UE dropping | Ericsson, Samsung, MediaTek, ZTE (but keep 2 UEs as well), IDC, Apple, LGE | The proposal (also the trajectory simplification from vivo) seems reasonable and adopted. For MPE, company is to report the number of UEs |
| 3 | UE and panel orientation assumption:  Alt1. vertical but random in azimuth  Alt2. company to report | Alt 1: Ericsson, Samsung (MPE), vivo, ZTE, IDC (MPE only), MediaTek, Huawei/HiSi, Intel, Apple, LGE  Alt2: Samsung, vivo (mobility) | Adopt the proposal for MPE. For mobility, the UE orientation is fixed (CPEs in a train, car-type UE or handset mounted on dashboard for highway). Companies should report the UE orientation assumption relative to the trajectory direction |
| 4 | Trajectory sampling at most spaced by decorrelation distance | Intel. Samsung, vivo, MediaTek, ZTE, Huawei/HiSi, Apple, LGE | Basic principle of trajectory sampling with sufficient distance granularity is reasonable, but companies should provide details as well |
| 5 | Assumption on car penetration loss | Vivo, Samsung, MediaTek, ZTE, LGE | Added **Table 5** to address the missing part and clarify that the loss always applies to the UE |
| 6 | Include UE rotation modeling as baseline | Support: Intel, IDC, Huawei/HiSi, Apple  Not support: Samsung, ZTE (ok as optional) | While this could be a factor for MPE (although it doesn’t seem agreeable), it is a non-issue for the mobility scenarios of interest. |
| 7 | Consider spatial consistency as baseline | Support: Huawei/HiSi, Intel, ZTE  Not support: Samsung, Apple | This feature hasn’t been widely implemented and calibrated during 5G channel model. |
| 8 | Dense Urban: 1 hexagonal site with 3 sectors 🡺 a site with 3 hexagonal sectors. | Support: Intel  Not support: Samsung, ZTE, Apple  Equivalent: Ericsson | Unclear benefit or difference over 1 hex 3 120-deg sectors, likely equivalent |
| 9 | For baseline, consider impairments: beam acquisition, indication, switching latency, random measurement error for L1-RSRP | Support: Intel (L1-RSRP), Apple. Ericsson (beam switching RAN4), Huawei/HiSi (beam acquisition), Intel (companies report)  Not support: Samsung (companies can state), ZTE (ok as optional) | Impairments are implementation-specific (difficult to align as baseline). Companies can provide results with impairments (and should report the assumptions) |
| 10 | Consider multiple UEs per cell for mobility as an additional baseline | Support: Samsung, Intel  Not support: ZTE (ok as optional) | More difficult to align results as baseline (e.g. trajectory model needs to be modified, scheduler assumption) |

The moderator observes the following:

* Issue 1: Since the same solution will be used to enhance both intra- and inter-cell mobility for high-speed and large number of configured TCI states, selecting the solution solely based on intra-cell mobility evaluation (while knowing that inter-cell mobility is the one causing system performance bottleneck and the more challenging scenario) is difficult to justify. Those proposing to forego EVM for inter-cell mobility argue mainly from the difficulty of modeling Rel.15/16 baseline performance.
* Issues 2-5: The inputs have been incorporated into the offline proposal prior to the contribution submission.
* Issues 6-10: Some additional add-ons to the offline proposal prior to the contribution submission were proposed (some new, other have been mentioned and discussed). Since these issues are more controversial to be incorporated into the baseline, they are left as optional, i.e. companies are welcomed to present additional results with such assumptions – as long as the details are clearly described to facilitate better alignment across presented results.

In light of this observation, the moderator proposals in section 2 have been refined.

**Table 8 Additional inputs from submitted contributions and subsequent offline**

|  |  |
| --- | --- |
| **Company** | **Input** |
| Samsung | **For item 1**: Support Alt1. Inter-cell mobility is part of the work item objectives, hence we support Alt1, to extend the trajectory to cross cell boundaries. There are two aspects to consider,   * First, the trajectory to follow. For dense urban it has been agreed to use 7 site x 3 sector per site scenario. We can simply extend the linear trajectory to cross multiple cells, as illustrated in the attached figure. It should be noted that this scenario includes realistic aspects, such as non-uniform intra-cell trajectory-distances. For the HST scenario a 6 RRH model has been agreed, wherein all 6 RRHs belong to the same cell. For the inter-cell scenario, the model is extended to have each three cells to be part of a cell. * Second, how to model impairments as a UE moves from one cell to the next. Modeling the detailed L3 mobility procedure, will be time consuming and not easy to align within a short time. As simple model can suffice, which includes a delay between the time the handover condition is fulfilled (e.g. based on the to the actual handover time. The delay can be a random variable, with mean and standard deviation . Companies to report on the values of and .     **For item 2**: There two aspects for beam management to consider. First higher mobility (i.e. faster speeds), for this a single user per cell can stress the relevant parts of the beam management algorithm. Hence, we are fine with having a scenario with a single user per cell. The second aspect is when users are moving together and are in close proximity, this is discussed as a second scenario under item 10.  The second part of item 2, i.e. random UE dropping for MPE is OK.  **For item 3**: This seems reasonable. But we prefer to allow companies to report on UE orientation assumptions.  **For item 4**: We support that the sample points along the trajectory are close enough to allow the detection of beam changes as they occur. Companies to provide details on the spacing of points along the trajectory.  **For item 5**: We support the parameters in Table 5.  **For item 10**: As discussed in item 2, there are two aspects to consider for beam management design enhancements; higher speeds and more users moving together. For higher speeds, a single user per cell is sufficient as discussed in item 2. For users moving together in a cell (e.g. in mass transportation), we should consider a second simulation scenario with multiple users in a cells.  **For item 6:** Don’t support for mobility. In HST, the UE, a CPE, has a fixed orientation. In car, UE can be mounted on dashboard with a fixed orientation.  **For item 7:** Don’t support. Spatial consistency, has not been implemented nor calibrated.  **For item 8:** Don’t support.  **For item 9:** Don’t support. Companies to report impairments considered. No need to agree on baseline values. |
| vivo | **For item1**:   * We sympathize the comment from E/// that the aligned simulation assumption on the legacy mobility procedure is challenging and may consume too much effort for RAN1 discussion.   **For item2**:   * We are supportive of reducing number of UEs to one for both mobility simulation and MPE simulation. * Moreover, we would like to fix the moving direction along trajectory as following to further align companies simulation results, rather than make the UE randomly pick the movement direction from cell to cell.     **For item3:**   * For the mobility related simulation, we would like to clarify   + For the CPE type UE in HST scenario, can we clarify the orientation of the panels of the CPE to the directions of movement along the railway? Fixed orientation seems more appropriate for such scenairos. Moreover, is it correct understanding that the CPE also has three panels?   + For the Dense Urban scenario with CAR type UE, can we also fix the orientation of the three panels with regards to the direction of movement along the highway? * For the MPE simulation assumption, we are ok with the E/// assumption on orientation.   **For item4:**   * We are fine with the clarification from Intel. Large scale parameters could be updated every 10ms.   **For item5:**   * We are supportive of adding the table. “Train penetration Loss” should be “car penetration loss”. * Is it correct understanding that the car penetration loss is applicable both for the CAR type UE (for mobility simualtion) and the UEs inside the car (for MPE simulation)? |
| MediaTek | **For Item 1:** Support **Alt 3.** Share similar view with Ericsson and vivo.  **For Item 2:**   * For intra-cell mobility, support one UE per cell. Purpose of dropping two associated UEs is not clear for evaluating beam management solutions. * For MPE mitigation and multi-panel UE, we support random UE dropping. However, we would like to clarify whether the number UE is also changed to 1 in this scenario. From our view, since performance gain from MPE mitigation or fast panel switching may depend on UE position and orientation, multiple UEs per cell dropped in random are still needed for evaluating the whole system gain.   **For Item 3:** Support fixed zenith angle of each UE panel to vertical (900), and random azimuth angle for the UE orientation, where the azimuth angle of each panel is fixed in relative to the UE orientation.  **For Item 4:** Reasonable but detail of sampling granularity along trajectory can be provided by companies.  **For Item 5:** Support the parameters in Table 5. |
| Ericsson | **On panel orientation:**  The current description of the UE panels state that they are all “tall”. For the left/right panels, this makes a lot of sense, but it may seem more realistic if the panel on the back is “wide”. We should confirm that all panels are “tall” if that is the intention. This would mean that each panel can only generate one beam in azimuth.  **On the UE transmit power:**  The UE transmit power specification seems to be inconsistent between table 1, table 3 and table 4.  **Issue 3:**  The random orientation would apply only to Dense urban. Similar to vivo, we feel that it would seem appropriate to have a fixed orientation, still vertical, with the right/left panels pointing right/left, and the back panel pointing back  **Issue 4:**  Should it be “at most spaced by decorrelation distance”? We should sample the trajectory often enough.  **Issue 5:**  Table 5 says “Train penetration loss”, should be “Car penetration loss”?  **Issue 8:**  It is our understanding that the layouts are equivalent  **Issue 9:**  It is our understanding that “beam acquisition delay” corresponds to the limitation in the RAN4 spec, so it is not necessarily an implementation issue. |
| ZTE | For item 1, Samsung’s suggestion seems to a good way-forward solution  For item 2,   * Regarding intra-cell mobility SLS: change # UEs per cell from 2 to 1, we are fine with this additional evaluation assumption. The current assumption 2 UEs per cel should also be kepted to emulate car(s) from opposite orientation; * Regarding MPE: random UE dropping, we can support it.   For item 3, we can support it  For item 4, we can support it, and the companies are encouraged to report the distance of neighboring samples along the trajectory.  For item 5, we can support the table 5, but “UE Tx Power = 23 dBm” can be removed in our views, due to the already agreed assumption of EIRP =22 dB in table 3.  For item 6, we can accept it as an add-on feature rather than baseline.  For item 7, spatial consistency should be considered as a basic requirement for emulating UE movement trajectory. Regarding the model of spatial consistency, we also prefer model-B in TS 38.901.  For item 8, the motivation of this proposal is unclear for us.  For item 9 and item 10, it can be assumed as an additional evaluation assumptions (optional), and the companies is encourage to provide the corresponding details if considered. |
| IDC | **Item 1**: Support Alt3. In order to have a meaningful conclusion, there are many additional details that need to be included making the evaluation very complex and time consuming.  **Item 2**: Support. The MU-MIMO performance aspect should be left out of evaluation.  **Item 3**: Support.  **Item 6**: It may make sense to combine **Items 3 & 6** together. |
| Huawei, HiSilicon | Item 1:   * Although HST is challenging in FR2, it is more beneficial for RAN1 to model each sector (out of three) at one site as one cell so that the layout can represent more complex deployment in Urban in FR2 and give rise to more inter-cell handover observations per simulation run. The setup may provide more interesting observations during RAN1 discussion. * With regarding to how to model traditional L3-HO, companies shall be encouraged to report RRM measurement arrangement (RS overhead, beamforming strategy at gNB/UE, reporting periodicity), triggering condition (criteria, thresholds), and benchmark performance (existence of service interruption, duration).   Item 3:   * Similar as vivo/Ericsson, we are supportive of fixing the orientation of three UE panels with regards to the moving direction. However, we are more inclined to have the back panel facing the moving direction, i.e. the front screen of the phone is to face the user in order to use apps (watching football during driving^-^).   Item 4:   * Such trajectory sampling can be more meaningful if spatial consistency in Item 7 is included as baseline. Otherwise it can be up to companies to report, if it is difficult to align further details of sampling in RAN1.   Item 6:   * Similar with Intel, we also fine to support UE rotation model since linear trajectory without turning points have been assumed here.   Item 7:   * Spatial consistency modelling is meaningful for beam tracking since trajectory sampling and UE movement over trajectory lines need to take into account spatial consistency and associated beam tracking/updating.   Item 9:   * We support including delay of beam acquisition, which is a major source of latency on beam tracking.   Other:  We similar view as Ericsson that it may be more realistic that the back panel is placed horizontally (in relative to UE). |
| Intel | **Item 1:**   * Handover modeling is very important for inter-cell mobility evaluation. The stochastic model may not capture the handover process accurately. Additionally, without detailed modeling, it is unclear what additional benefits inter-cell simulations provide. * We prefer Alt. 3.   **Item 2:**   * We prefer to have 1 UE per cell. Benefits of 2 UEs per cell for evaluation of beam management is not clear. * We additionally have concerns on the lack of randomness in UE drops. Since the UE is always dropped at the corner of the trajectory and all UEs in the system move in a somewhat coordinated manner, the gNB beams always start from pointing at the cell-edge. The interference modeling for such implementation is not dynamic. * We propose the following alternatives:   + Alt 1: *Consider single cell with 1 UE*, since there is very limited (and mostly static) interference in current model and the use of 21 cell simulation is unclear.   + Alt 2: *Introduce randomness in UE drops* i.e., the UE can be dropped anywhere on the trajectory and once UE reaches an endpoint, it can turn around follow the reverse trajectory   **Item 3:**   * Ok with proposal from Ericsson. Additionally, Item 6 can be combined with this assumption.   **Item 4:**   * The proposal is that UE trajectory should be sampled at least at a distance less than the minimum decorrelation distance of the large-scale parameters for the given evaluation scenario * This would ensure LSP are sampled often enough   **Item 6:**   * Our initial results indicate that without UE rotation, beam tracking performance is close to ideal. This does not reflect a real-world UE operating in mm Wave and would yield optimistic simulation results.   **Item 7:**   * Our initial evaluations show that modeling some form of spatial consistency is vital for trajectory-based mobility simulations. If not modeled RSRP values have a large dynamic range especially since SF has a standard deviation of 8dB according to 38.901. * Without spatial consistency L1-RSRP across trajectory points may not be realistic and would lead to possibly incorrect conclusions from simulations * Since this is a new type of evaluation being considered in RAN1, we strongly suggest spatial consistency should be considered as a baseline since previously, only drop based simulations were used in RAN1 where UE does not change physical position during the simulation * Companies can report their overall assumptions for spatial consistency at least for LSP and provide traces to show smooth variation across trajectory   **Item 8:**   * If considering an ISD of 200m, the models should be similar.   **Item 9:**   * The main purpose of this modeling is to account for real impairments * Companies should report assumptions. * If not modeled, simulation results can be optimistic |
| Apple | **Item 1:** Support Alt1  **Item 2:** Support  **Item 3:** Support  **Item 4:** Support  **Item 5:** Open to include this car penetration loss  **Item 6:** Support  **Item 7:** Do not support  **Item 8:** Do not support  **Item 9:** We recommend to consider RSRP measurement accuracy, especially for inter-cell mobility. Currently we are not sure whether L1-RSRP would result in some pingpong issue or not.  **Item 10:** We can consider multiple drops to model multi-UEs. |
| LG | **For item1:**  Support Alt3 with similar view of Ericsson. In addition, the stochastic HO assumption in the SLS may not verify the performance gain for inter-cell scenario.  **For item2:**  Regarding to intra-cell mobility, we support one-UE assumption that the two associated-UEs seems not clear for validating the benefits of potential BM solutions.  For MPE case, the random UE dropping is reasonable.  **For item3:**  Support the Ericsson’s view that the orientation of the UE panels is set based on the moving direction.  **For item4:**  Support by providing the details on sampling granularity (distance) along the trajectory.  **For item5:**  Is it correct understanding that ‘Train penetration loss’ is replaced by ‘Car penetration loss’?  Moreover, it needs to be aligned on the component of UE transmit power compared to other tables. |

# References

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2. R1-2005290 Enhancement on multi-beam operation Futurewei
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4. R1-2005454 Enhancements on Multi-beam Operation ZTE
5. R1-2005482 Enhancements on Multi-beam Operation Interdigital Inc.
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8. R1-2005683 Discussion on enhancement on multi-beam operation CATT
9. R1-2005750 Discussion on multi-beam operation NEC
10. R1-2005782 Enhancements on multi-beam operation Fraunhofer IIS, Fraunhofer HHI
11. R1-2005820 Enhancements on multi-beam operation Lenovo, Motorola Mobility
12. R1-2005842 Enhancements on multi-beam operation Ericsson
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17. R1-2006200 Enhancements on multi-beam operation CMCC
18. R1-2006248 Enhancements on multi-beam operation Spreadtrum Communications
19. R1-2006499 On Beam Management enhancement Apple
20. R1-2006540 Enhancements on multi-beam operation Beijing Xiaomi Electronics
21. R1-2006565 Enhancement on multi-beam operation for UE with multi-panel Sharp
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25. R1-2006790 Enhancements on Multi-beam Operation Qualcomm Incorporated
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