3GPP TSG RAN WG1 #101 R1-20xxxxx

**e-Meeting, May 25th – June 5th, 2020**

**Agenda item: 8.4.1**

**Source: Moderator (China Telecom)**

**Title: [101-e-NR-Cov-Enh] Email discussion on evaluation methodology and simulation assumptions for NR coverage enhancements**

**Document for: Discussion and Decision**

# Introduction

In RAN #86 meeting, a new Rel-17 study item on NR coverage enhancements was approved [1]. The objective of this study item is to study potential coverage enhancement solutions for specific scenarios for both FR1 and FR2. The detailed objectives are as follows.

* *The target scenarios and services include*
  + *Urban (outdoor gNB serving indoor UEs) scenario, and rural scenario (including extreme long distance rural scenario) for FR1*
  + *Indoor scenario (indoor gNB serving indoor UEs), and urban/suburban scenario (including outdoor gNB serving outdoor UEs and outdoor gNB serving indoor UEs) for FR2.*
  + *TDD and FDD for FR1.*
  + *VoIP and eMBB service for FR1.*
  + *eMBB service as first priority and VoIP as second priority for FR2.*
  + *LPWA services and scenarios are not included.*
* *Identify baseline coverage performance for both DL and UL for the above scenarios and services based on link-level simulation*
  + *UL channels (including PUSCH and PUCCH) are prioritized for FR1.*
  + *Both DL and UL channels for FR2.*
* *Identify the performance target for coverage enhancement, and study the potential solutions for coverage enhancements for the above scenarios and services*
  + *The target channels include at least PUSCH/PUCCH*
  + *Study enhanced solutions, e.g., time domain/frequency domain/DM-RS enhancement (including DM-RS-less transmissions)*
  + *Study the additional enhanced solutions for FR2 if any*
  + *Evaluate the performance of the potential solutions based on link level simulation.*

This contribution summarizes the email discussion on evaluation methodology and simulation assumptions for NR coverage enhancements.

# Discussion

## 2.1 FR1

## 2.2 FR2

2.2.1 Target data rates for FR2

(1) eMBB

Based on SID, the target data rates for FR2 were identified as follows, which need to be further discussed:

- Indoor: DL: 25Mbps UL:5Mbps

- Urban: DL: [25Mbps] UL: [5Mbps]

- Suburban: DL: [1Mbps] UL: [50kbps]

Companies are invited to provide views on the target data rates for FR2.

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| **Companies** | **Comments** |
| CATT | Support |
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(2) VoIP

**Proposal:**

* **The codec of VoIP for FR2 is the same as FR1**

Companies are invited to provide views on the above proposal.

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| **Companies** | **Comments** |
| CATT | Support |
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2.2.2 Evaluation methodology

Based on the companies’ input for the evaluation methodology, there are two options summarized below.

* **Option 1: Based on link-level simulation**
* Step 1: Obtain the required SINR for the target physical channel under target scenarios and services.
* Step 2: Obtain the baseline performance based on required SINR and link budget template.
* Step 3: Obtain the target performance based on the target performance metric.

Support: Huawei, HiSilicon, CATT, vivo, Intel, Samsung, Nokia, Nokia Shanghai Bell, Sony, CMCC, Charter, InterDigital, NTT DOCOMO, Qualcomm (14 companies)

* **Option 2: Based on link-level and system-level simulation**
* Step 1: Obtain the required SINR for the target physical channel under target scenarios and services based on link-level simulation.
* Step 2: Obtain the target performance based on system-level simulation (i.e. the 5th percentile downlink or uplink SINR value in CDF curve).

Support: Ericsson, ZTE (2 companies)

We have the following proposal:

**Proposal:**

* **The evaluation methodology for FR2 is the same as FR1.**

Companies are invited to provide views on the above proposal.

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| **Companies** | **Comments** |
| CATT | Support |
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2.2.3 Simulation assumptions for obtaining the required SINR

* Data channel

Companies are encouraged to provide views on the simulation assumptions for data channel including PUSCH and PDSCH in the following table.

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| **Parameters and descriptions** | **Companies** | **Comments** |
| **Frequency:**   * Option 1: 30GHz   (Huawei, Hisilicon, vivo, Samsung, Nokia, Nokia Shanghai Bell, Ericsson)   * Option 2: 28GHz   (CATT, Intel, NTT DOCOMO, Qualcomm)   * Option 3: 26GHz   (CMCC) | **CATT** | Considering the operating band defined in Table 5.2-1 captured by TS38.101-2, we prefer 28 GHz. |
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| **Frame structure for TDD:**   * Option 1: DDDSU (10D:2G:2U) (Huawei, Hisilicon, Ericsson, Nokia, Nokia Shanghai Bell) * Option 2: DDDSUDDSUU   (10D:2G:2U) (vivo, CATT)   * Option 3: DDSU (D:U=3:1)   (NTT DOCOMO, Qualcomm) | **CATT** | We are also fine with Option1 |
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| **Subcarrier Space:**   * Option 1: 120kHz   (Huawei, Hisilicon, vivo, Samsung, Nokia, Ericsson, NTT DOCOMO, Qualcomm)   * Option 2: 60kHz   (CATT, Intel) | **CATT** | We are also fine with option 1 |
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| **BLER:**   * Option 1: 10% for eMBB & 2% VoIP rBLER (Samsung) * Option 2: 10% for eMBB   (Huawei, Hisilicon, vivo, CATT)   * Option 3: 2% rBLER   (NTT DOCOMO) |  |  |
| **CATT** | Not sure which traffic type is in mind for option 3. Is it for VoIP? We think the BLER for VoIP should also be addressed and fine with set 2% rBLER for it. |
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| **UE velocity:**  Indoor:   * 3km/h   (Huawei, HiSilicon, vivo, CATT, Samsung, Nokia, Ericsson, Qualcomm)  Urban:   * Option 1: 3km/h for indoor, 30km/h for outdoor   (vivo, Samsung, Nokia, Nokia Shanghai Bell, Ericsson)   * Option 2: 3km/h   (Huawei, HiSilicon, CATT, Qualcomm)  Suburban   * Option 1: 3km/h for indoor, 120km/h for outdoor   (Samsung, Nokia Nokia Shanghai Bell)   * Option 2: 3km/h for indoor, 30km/h for outdoor (Ericsson) * Option 3: 3km/h   (Huawei, HiSilicon, CATT) |  |  |
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| **Number of receive antenna elements for BS:**  Rural:   * Option 1: 256   (Huawei, Hisilicon, Qualcomm)   * Option 2: 128 (Ericsson) * Option 3: 64 (Samsung) * Option 4: 32 (vivo) * Option 5: 8 (Nokia, Nokia Shanghai Bell)   Urban:   * Option 1: 256   (Huawei, Hisilicon, vivo Samsung)   * Option 2: 128   (Nokia, Nokia Shanghai Bell)   * Option 3: 512 (Ericsson)   Suburban:   * Option 1: 256   (Huawei, Hisilicon, vivo Samsung)   * Option 2: 128   (Nokia, Nokia Shanghai Bell)   * Option 3: 512 (Ericsson)   **Number of receive TxRUs for BS:**   * Option 1: 2 * Option 2: Other value |  |  |
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| **Number of receive antenna elements for UE:**  Indoor   * Option 1: 16   (Huawei, Hisilicon, vivo)   * Option 2: 2   (Samsung, Ericsson)   * Option 3: 4   (Qualcomm, Nokia, Nokia Shanghai Bell)  Urban   * Option 1: 16   (Huawei, Hisilicon, vivo)   * Option 2: 2   (Samsung, Ericsson)   * Option 3: 4   (Qualcomm, Nokia, Nokia Shanghai Bell)  Suburban   * Option 1: 16   (Huawei, Hisilicon, vivo)   * Option 2: 2   (Samsung, Ericsson)   * Option 3: 4   (Nokia, Nokia Shanghai Bell)  **Number of receive TxRUs for UE:**  UL:   * Option 1: 2   (Huawei, Hisilicon, CATT, Samsung, NTT DOCOMO)   * Option 2: 1   (vivo, Intel, Nokia, Nokia Shanghai Bell, Ericsson)  DL:   * Option 1: 2 * Option 2: Other value |  |  |
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| **Channel model and delay spread for link-level simulation**  Indoor:   * Option 1: TDL-A [26,10,20,30] ns   (vivo, NTTDOCOMO, CATT, Nokia, Nokia Shanghai Bell, Ericsson)   * Option 2: CDL-A/B/C, [30,43,100] ns   (Samsung, Qualcomm, Huawei, Hisilicon)  Urban   * Option 1: TDL-A   [20,60, 266,262,300] ns  (vivo, NTTDOCOMO, Nokia, Nokia Shanghai Bell, CATT, Ericsson)   * Option 2: CDL-A/B/C, [30,100,616] ns   (Samsung, Qualcomm, InterDigital, Huawei, Hisilicon)  Suburban   * Option 1: TDL-A   [20,60,266,262,300] ns  (vivo, NTTDOCOMO, Nokia, Nokia Shanghai Bell, CATT, Ericsson)   * Option 2: CDL-A/B/C, [30,100,616] ns   (Samsung, Qualcomm, InterDigital, Huawei, Hisilicon) | CATT | For urban scenario, although our position is TDL-C, we can follow majority view. But would like to raise one comment: TDL-C is assumed for urban scenario in 38.901, I am not sure why TDL-A is assumed here. |
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| **Occupied channel bandwidth & PRBs**  Indoor:   * Option 1: 100MHz (66 PRBs)   (Huawei, Hisilicon, Ericsson, Qualcomm)   * Option 2: [15,20,28,30] PRBs   (vivo, Intel, CMCC, Samsung)   * Option 3: 200MHz   (Nokia, Nokia Shanghai Bell)   * Option 4: 400MHz (NTT DOCOMO)   Urban   * Option 1: 100MHz (66 PRBs)   (Huawei, Hisilicon, Ericsson, Qualcomm)   * Option 2: [15,20,28,30] PRBs   (vivo, Intel, CMCC, Samsung)   * Option 3: 200MHz   (Nokia, Nokia Shanghai Bell)   * Option 4: 400MHz (NTT DOCOMO)   Suburban   * Option 1: 100MHz (66 PRBs)   (Huawei, Hisilicon, Ericsson, Qualcomm)   * Option 2: [1,4] PRBs (Intel, Samsung) * Option 3: 200MHz   (Nokia, Nokia Shanghai Bell)   * Option 4: 400MHz (NTT DOCOMO) |  |  |
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| **TBS and MCS:**   * Option 1: TBS and MCS can be calculated based on the number of PRBS, target data rate, frame structure and overhead. * Option 2: Fixed value of TBS and MCS for each scenario. | CATT | Same views as FR1. The key issue is to determine all the relevant parameters, such as PRB, data rate, frame structure, overhead. If we are on the same page for the aforementioned parameters (this is we have to before LLS), we don’t see any difference between option 1 and option 2. |
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| **Number of repetitions for PUSCH and PDSCH** | CATT | Similar views as FR1. It will be a trade-off between the number of repetition and the final performance. May be better to be provided by each companies when submit simulation results. |
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| **Frequency hopping for PUSCH and PDSCH** | CATT | On for PUSCH. For PDSCH, there is no frequency hopping. The intention is to enable VRB-to-PRB interleaving? We think it should be enabled. |
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| **HARQ configuration** | CATT | Same comments for FR1: No sure whether we need to consider re-transmission. The HARQ gain has been considered in link budget template. |
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| **DMRS configuration** | CATT | We prefer to use the same DMRS configuration as FR1. |
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| **Other parameters** | CATT | The DMRS power boosting should also be considered for PUSCH transmission. |
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* PUCCH

Most parameters for PUCCH can be reused from PUSCH, companies are encouraged to provide views on the simulation assumptions for PUCCH in the following table.

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| **Format type**  Format 1:  (long PUCCH with 14 OFDM symbols)   * Option 1: 1 bit   (Huawei, Hisilicon, CATT, Intel, Qualcomm)   * Option 2: 2 bits   (ZTE, vivo, Samsung, Nokia, Nokia Shanghai Bell)  Format 3:   * Option 1: [6,8,11]bits   (vivo, ZTE, Qualcomm)   * Option 2: [20,22] bits   (ZTE,Nokia, Nokia Shanghai Bell)   * Option 3: 50 bits (Intel)   Format 2:   * For eMBB with 8bits UCI. Format 0 for VoIP with 1bit (NTT DOCOMO) |  |  |
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| **Scheduled PRBs:**   * Option 1: 1 * Option 2: other values |  |  |
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| **Other parameters** |  |  |
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* PDCCH

Most parameters for PDCCH can be reused from PDSCH, companies are encouraged to provide views on the simulation assumptions for PDCCH in the following table.

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| **Format and payload:**  **DCI format:**   * Option 1: format 1-0 * Option 2: format 0-0   **DCI size:**   * 64 bits, AL = 16 (Huawei, HiSilicon) * 39bits, AL = 8 (vivo) * 40 bits, AL = 4 (Intel) * DCI size = 68 bits, AL =16 (Samsung) * DCI payload = 40bits+ CRC 24bits, AL = 16   (Nokia, Nokia Shanghai Bell, Ericsson) | CATT | DCI format doesn’t matter as format 1-0 and format 0-0 have same payload size in the same SS.  For the DCI size, we should spell out the payload size and the CRC. From the current options, I am not sure, e.g. 64 btis, whether they includes CRC or not. |
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| **CORESET:**   * Option 1: 2 symbols * Option 2: other values | CATT | 3 symbols may be better if we want to use distributed mapping. |
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| **Scheduled PRBs:**   * Option 1: 48 * Option 2: other values | CATT | Should be aligned with the bandwidth assumption of PDSCH. |
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| **Other parameters** | CATT | At least the following parameters should be clarified:  Mapping type, REG bundle size, wide-band RS or not. |
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* PRACH

Most parameters for PRACH can be reused from other channels, companies are encouraged to provide views on the simulation assumptions for PRACH in the following table.

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| **Format type**   * Option 1: Format B4   (Intel, Ericsson, Qualcomm, vivo)   * Option 2: Format C2   (CMCC, Huawei, HiSilicon) |  |  |
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| **Scheduled PRBs:**   * Option 1: 12 * Option 2: other values |  |  |
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| **Performance metric:**   * Option 1: 0.1% false alarm * Option 2: 1% miss-detection * Option 3: 0.1% false alarm, 1% miss-detection |  |  |
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| **Other parameters** |  |  |
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2.2.4 Link budget template

There are two main options for the link budget template.

* **Option 1-1: Adopt link budget template in IMT-2020 self-evaluation**
* The calculated available path loss is considered as the baseline performance.

Support: Huawei, Hisilicon, ZTE, vivo, CATT, Samsung, Nokia, Nokia Shanghai Bell (8 companies)

* **Option 1-2: Adopt MCL calculation template**
* The calculated MCL is considered as the baseline performance.
* Note: Details are not provided yet.

Support: Intel, NTT DOCOMO, Charter, InterDigital (4 companies)

Companies are invited to provide views on the above options.

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| **Companies** | **Comments** |
| CATT | Option 1-1. It has been well-verified in ITU and is sufficient for NR coverage evaluation. Option 1-2 was used for LTE coverage evaluation and may be not so suitable for NR as option 1-1. |
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1. **Link budget template in IMT-2020 self-evaluation**

For the link budget template employed in IMT-2020 self-evaluation, most parameters and values can be reused. While based on the companies’ inputs, some parameters identified with TBD (To Be Determined) in Table E need to be discussed and determined.

In order to facilitate discussion on simulation assumptions, we have the following proposal:

**Proposal:**

* **For link budget template in IMT-2020 self-evaluation, adopt Table E for the baseline performance calculation for FR2.**

Table E Link budget template in IMT-2020 self-evaluation for FR2

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| **Parameter** | **Values** |
| Scenario | TBD |
| Frame structure | TBD |
| Carrier frequency (Hz) | TBD |
| BS antenna heights (m) | 3m for indoor hotspot, 25m for urban & suburban |
| UT antenna heights (m) | 1.5 |
| Cell area reliability for control channel | 95% |
| Cell area reliability for data channel | 90% |
| Transmission bit rate for control channel (bit/s) | TBD |
| Transmission bit rate for data channel (bit/s) | TBD |
| Target packet error rate for the required SNR in item (19a) for control channel | 1% |
| Target packet error rate for the required SNR in item (19b) for data channel | TBD |
| Spectral efficiency (bit/s/Hz) | TBD |
| Pathloss model (select from LoS or NLoS) | TBD |
| UE speed (km/h) | TBD |
| Feeder loss (dB) | 3 |
| **Transmitter** | |
| (1) Number of transmit antennas. (The number shall be within the indicated range in § 8.4 of Report ITU-R M.2412-0) | TBD |
| (1bis) Number of transmit antenna ports | TBD |
| (2) Maximal transmit power per antenna (dBm) | TBD |
| (3) Total transmit power = function of (1) and (2) (dBm) (The value shall not exceed the indicated value in § 8.4 of Report ITU-R M.2412-0) | TBD |
| (4) Transmitter antenna gain (dBi) | 0 for UL, 8 for DL |
| (5) Transmitter array gain (depends on transmitter array configurations and technologies such as adaptive beam forming, CDD (cyclic delay diversity), etc.) (dB) | TBD |
| (6) Control channel power boosting gain (dB) | 0 |
| (7) Data channel power loss due to pilot/control boosting (dB) | 0 |
| (8) Cable, connector, combiner, body losses, etc. (enumerate sources) (dB) (feeder loss must be included for and only for downlink) | TBD |
| (9a) Control channel EIRP = (3) + (4) + (5) + (6) – (8) dBm | - |
| (9b) Data channel EIRP = (3) + (4) + (5) – (7) – (8) dBm | - |
| **Receiver** | |
| (10) Number of receive antennas (The number shall be within the indicated range in § 8.4 of Report ITU-R M.2412-0) | TBD |
| (10bis) Number of receive antenna ports | TBD |
| (11) Receiver antenna gain (dBi) | TBD |
| (11bis) Receiver array gain (depends on transmitter array configurations and technologies such as adaptive beam forming, etc.) (dB) | TBD |
| (12) Cable, connector, combiner, body losses, etc. (enumerate sources) (dB) (feeder loss must be included for and only for uplink) | TBD |
| (13) Receiver noise figure (dB) | 5 for UL, 7 for DL |
| (14) Thermal noise density (dBm/Hz) | -174 |
| (15a) Receiver interference density for control channel (dBm/Hz) | TBD |
| (15b) Receiver interference density for data channel (dBm/Hz) | TBD |
| (16a) Total noise plus interference density for control channel = 10 log (10^(((13) + (14))/10) + 10^((15a)/10)) dBm/Hz | - |
| (16b) Total noise plus interference density for data channel = 10 log (10^(((13) + (14))/10) + 10^((15b)/10)) dBm/Hz | - |
| (17a) Occupied channel bandwidth for control channel (for meeting the requirements of the traffic type) (Hz) | TBD |
| (17b) Occupied channel bandwidth for data channel (for meeting the requirements of the traffic type) (Hz) | TBD |
| (18a) Effective noise power for control channel = (16a) + 10 log((17a)) dBm | - |
| (18b) Effective noise power for data channel = (16b) + 10 log((17b)) dBm | - |
| (19a) Required SNR for the control channel (dB) | Obtained from link-level simulation |
| (19b) Required SNR for the data channel (dB) | Obtained from link-level simulation |
| (20) Receiver implementation margin (dB) | 2 |
| (21a) H-ARQ gain for control channel (dB) | 0 |
| (21b) H-ARQ gain for data channel (dB) | 0.5 |
| (22a) Receiver sensitivity for control channel = (18a) ++ (19a) + (20) – (21a) dBm | - |
| (22b) Receiver sensitivity for data channel = (18b) ++ (19b) + (20) – (21b) dBm | - |
| (23a) Hardware link budget for control channel = (9a) + (11) + (11bis) − (22a) dB | - |
| (23b) Hardware link budget for data channel = (9b) + (11) + (11bis) − (22b) dB | - |
| **Calculation of available pathloss** | |
| (24) Lognormal shadow fading std deviation (dB) | TBD |
| (25a) Shadow fading margin for control channel (function of the cell area reliability and (24)) (dB) | TBD |
| (25b) Shadow fading margin for data channel (function of the cell area reliability and (24)) (dB) | TBD |
| (26) BS selection/macro-diversity gain (dB) | 0 |
| (27) Penetration margin (dB) | TBD |
| (28) Other gains (dB) (if any please specify) | 0 |
| (29a) Available path loss for control channel = (23a) – (25a) + (26) – (27) + (28) – (12) dB | - |
| (29b) Available path loss for data channel = (23b) – (25b) + (26) – (27) + (28) – (12) dB | - |
| **Range/coverage efficiency calculation** | |
| (30a) Maximum range for control channel (based on (29a) and according to the system configuration section of the link budget) (m) | Note 1 |
| (30b) Maximum range for data channel (based on (29b) and according to the system configuration section of the link budget) (m) | Note 1 |

Note 1: The channel model for path loss calculation is defined in Report ITU-R M.2412 [3].

Companies are invited to provide views on the above proposal.

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| **Companies** | **Comments** |
| CATT | Support the proposal. We need to clarify which channel model is used for the evaluation.  Although there is no harm to maintain spectral efficiency in the template, we would like to remind that SE is not used in the link budget template. Furthermore, it is determined by the data rate and the frame structure. Once both data rate and frame structure are determined, the SE will be calculated automatically in the template. |
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Companies are encouraged to provide views on the parameters with TBD in Table E.

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| **Parameters and descriptions** | **Companies** | **Comments** |
| **Transmitter Cable, connector, combiner, body losses, etc. (enumerate sources) (feeder loss must be included for and only for uplink)**   * Option 1: The same value in IMT-2020.   1dB for UL, 3dB for DL   * Option 2: Other values | **CATT** | **Option1** |
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| **Receiver array gain for BS**   * Option 1: Reuse the formula in IMT-2020 self-evaluation to calculate the array gain,   array gain = 10 \* 1og10 (number of receive antennas/number of receive TxRUs)   * Options 2: Other methods | **CATT** | **Option1** |
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| **Receiver interference density for control channel**   * Option 1: The same value in IMT-2020.   -161.70 dBm/Hz for UL, -169.30 dBm/Hz for DL.   * Option 2: Other values | **CATT** | **Option1** |
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| **Receiver interference density for data channel**   * Option 1: The same value in IMT-2020.   -165.70 dBm/Hz for UL, -169.30 dBm/Hz for DL.   * Option 2: Other values | **CATT** | **Option1** |
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| **Receiver Cable, connector, combiner, body losses, etc. (enumerate sources) (feeder loss must be included for and only for uplink)**   * Option 1: The same value in IMT-2020.   1dB for DL, 3dB for UL   * Option 2: Other values | **CATT** | **Option1** |
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| **Lognormal shadow fading std deviation for control channel** |  |  |
|  |  |
|  |  |
| **Shadow fading margin for control channel** |  |  |
|  |  |
|  |  |
|  |  |
|  |  |
| **Lognormal shadow fading std deviation for data channel** |  |  |
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|  |  |
|  |  |
|  |  |
| **Shadow fading margin for data channel** |  |  |
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|  |  |
| **Penetration margin** |  |  |
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| **Other parameters** |  |  |
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1. **MCL calculation template**

Due to lack of sufficient inputs and detailed simulation assumptions for other MCL calculation template, we would like to invite companies to provide further views and comments.

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| **Companies** | **Comments** |
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2.2.5 Other channels for FR2

Due to lack of sufficient inputs and detailed simulation assumptions for other channels, e.g. Msg3, SSB/PBCH, we would like to invite companies to provide further views and comments.

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| --- | --- | --- |
| **Channel** | **Companies** | **Comments** |
| Msg3 |  |  |
|  |  |
|  |  |
| SSB/PBCH |  |  |
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|  |  |
| Other channels |  |  |
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2.2.6 Target performance metric

There are two main options for the target performance metric.

* **Option 1: The target path loss derived from the target ISD is considered as the target performance.**
* **Option 2: The target MCL is considered as the target performance.**

Companies are invited to provide views on the above options.

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| --- | --- |
| **Companies** | **Comments** |
| CATT | Option 1 |
|  |  |
|  |  |

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# Appendix