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 |
| Samsung | We support the proposal. |
| ZTE | We are fine with above target data rates for FR2 as a baseline. |
| NTT DOCOMO | We are fine for the target data rate for Indoor and Urban. For Suburban we are fine, on the other hand, we prefer 200 kbps for UL to align with DL and UL ratio (5 : 1) for Indoor and Urban. |

(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 |
| Samsung | We support the proposal. As commented in FR1, we also want to focus on the determination of TBS size. We prefer to determine TBS of 304 bits with 20ms data arriving interval as the starting point. |
| ZTE | Support the proposal. More precisely, we support of reusing the same TBS (320 bits) and data arriving interval (20 ms) as FR1. |
| NTT DOCOMO | We support the proposal. |

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 |
| Samsung | We support the proposal. |
| ZTE | Support the proposal.  Regarding the two options, we have the same understanding as FR1. To be short, we are fine with Option 1 while also see the necessity of Option 2.  One note for link budget template borrowed from ITU self-evaluation, we only have suggested values for FR1 in TS 37.910 while not for FR2. So, we may need more careful discussion on the detailed values for each components in the link budget template. |
| NTT DOCOMO | We support the proposal. |
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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. |
| Samsung | We are fine with Option 2. |
| ZTE | We prefer Option1 as in our paper, while also open for other options. |
| NTT DOCOMO | We support Option 2, since 28 GHz is the centre frequency of n257. 30 GHz and 26 GHz are edge or out of 3GPP bands. |
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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 |
| Samsung | We support Option 1 and 2. |
| ZTE | We prefer Option2 as in our paper, while also open for other options. |
| NTT DOCOMO | We support Option 1. |
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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 |
| Samsung | We support Option 1. |
| ZTE | We prefer Option1 as in our paper. |
| NTT DOCOMO | We support 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. |
| Samsung | We prefer Option 1 and prefer to consider the residual BLER for eMBB with low data rate in suburban scenario. In case of low data rate, it has a potential to get a significant gain by HARQ retransmission and slot aggregation compared to high data rate. |
| ZTE | Option 1 as FR1 |
| NTT DOCOMO | We prefer to use rBLER for both eMBB and VoIP to consider HARQ process. |
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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) | Samsung | We prefer Option 1 for both urban and suburban. |
| ZTE | Prefer 3km/h for indoor, and both Option 1 for urban and suburban. |
| NTT DOCOMO | We prefer to use a single parameter for Outdoor and Indoor for each scenarios, and thus we support 3km/h. |
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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 | Samsung | We prefer Option 1 for both urban and suburban. For Indoor scenario, we prefer Option 3 less than the number of receive antenna elements for urban/suburban scenario. For Number of receive TxRUs for BS, we prefer Option 1. |
| ZTE | Regarding the antenna elements: we prefer Option 3 for indoor, and both Option 1 for urban and suburban.  Regarding TxRUs, We support Option 1. |
| NTT DOCOMO | **Number of receive antenna elements for BS:**  In our understanding, number of antenna elements is for the link budget, not for the LLS. We are open for the number, on the other hand, we think we don’t have to define the number if MCL approach is selected.  **Number of receive TxRUs for BS:**  We support Option.1. |
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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 | Samsung | Our preference listed in left table was wrong. For the number of receive antenna elements, we prefer 4 or 8. For the number of TXRU, we prefer 2 for both DL and UL. |
| ZTE | Regarding the antenna elements: we prefer Option 1 for all scenarios.  Regarding TxRUs, We support Option 1 for both transmitting and receiving. |
| NTT DOCOMO | **Number of receive antenna elements for UE:**  In our understanding, number of antenna elements is for the link budget, not for the LLS. We are open for the number, on the other hand, we think we don’t have to define the number if MCL approach is selected.  **Number of receive TxRUs for UE:**  We support Option.1, since UE may have 2 antennas for MIMO transmission. |
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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. |
| Samsung | We prefer Option 2 for all scenarios. |
| ZTE | Option 2 with CDL channels is ok for us. |
| NTT DOCOMO | We prefer Option 1. |
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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) | Samsung | For DL data channel, we prefer 100MHz in occupied channel bandwidth and PRBs. For UL data channel, we prefer 30 PRBs for indoor and urban scenario and prefer 4 PRBs for suburban scenario. |
| ZTE | For system bandwidth, we propose to use 160MHz, but would be also ok with other options. For the number of RBs used, we prefer more combinations of (#RB, MCS index) considered and the one with best performance is chosen. If only one RB number is chosen, we prefer the following values for eMBB:  Indoor and Urban: 15 PRBs  Suburban: 1 PRB  For VoIP: 4 PRBs |
| NTT DOCOMO | We prefer Option 4, the maximum bandwidth. Allocated PRBs for each channels can be selected by each companies, e.g. 1 PRB for PDSCH (VoIP), and 25 PRBs for PDSCH (25 Mbps eMBB). |
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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. |
| Samsung | As commented in FR1, if RAN1 has the same understanding on how to calculate the TBS in option 1, we think option 1 and option 2 are the same. It would be better to discuss the TBS calculation method how to apply the number of PRBs, target data rate, frame structure and overhead. |
| ZTE | Option 1 is preferred with more combinations of (#RB, MCS index) considered and the one with best performance is chosen. But we are also OK with Option 2. |
| NTT DOCOMO | We support Option 1. |
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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. |
| Samsung | In case of low data rate, it has a potential to get a significant gain by HARQ retransmission and slot aggregation compared to high data rate. Therefore, we prefer to apply the repetition for PUSCH and PDSCH with low data rate. The number of repetitions for PUSCH and PUCCH can be set depending on the TDD configuration and data rate for PDSCH and PUSCH. |
| ZTE | For VoIP, PUSCH repetitions should be enabled. Repetition number 2 or 4 or 8 can be considered. |
| NTT DOCOMO | We prefer to follow FR1. |
| **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. |
| Samsung | Inter-slot frequency hopping is preferred with slot aggregation. |
| ZTE | Frequency hopping is enabled. Intra-slot frequency hopping is slightly preferred with slot aggregation. |
| NTT DOCOMO | We prefer to follow FR1. |
| **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. |
| Samsung | For VoIP and eMBB with low data rate, the number of HARQ retransmission should be set based on frame structure and latency requirement.  For eMBB with high data rate, we support no retransmission. |
| ZTE | For PUSCH carrying VoIP, a maximum of 4 re-transmissions (including the initial transmission) is preferred.  For PUSCH with eMBB, no re-transmission is assumed for10%iBLER. |
| NTT DOCOMO | We prefer to follow FR1. |
| **DMRS configuration** | CATT | We prefer to use the same DMRS configuration as FR1. |
| Samsung | * For 3km/h:   + 1 DMRS symbol * For 30km/h and 120km/h:   2 DMRS symbol (one front- loaded and one additional) |
| ZTE | One DMRS per hop. |
| NTT DOCOMO | We prefer to use dense configuration, e.g. 2 DMRS symbols (one front- loaded and one additional) for 14 symbols. |
| **Other parameters** | CATT | The DMRS power boosting should also be considered for PUSCH transmission. |
| ZTE | The waveform should be clarified. In our view, OFDM is used for DL and DFT-S-OFDM is for UL. |
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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) | Samsung | We prefer to focus on Format 1 for PUCCH. Since Format 1 is introduced for UCI with high priority and long coverage, in terms of coverage, PUCCH format 1 is prioritized.  We prefer Option 2 for format 1. |
| ZTE | Our preference is Format 1 with 2 bits and PUCCH format 3 with 11 and 22bits should be prioritized. |
| NTT DOCOMO | We support to use short format for FR2 with considering beam management. |
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| **Scheduled PRBs:**   * Option 1: 1 * Option 2: other values | ZTE | We support Option 1 |
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| **Other parameters** | ZTE | BLER target needs clarification. Our preference is follows.  For PUCCH format 1: DTX to ACK probability: 1% , NACK to ACK probability: 0.1%, ACK missed detection probability: 1%.  For PUCCH format 3: Block error probability: 1% |
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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. |
| ZTE | The payload size is more relevant here, and we prefer information bits of 40 bits with AL=16. |
| NTT DOCOMO | We prefer to use 24 bits with considering DCI format 2\_0, on the other and we are open for the payload size. |
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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. |
| ZTE | Option 1 |
| NTT DOCOMO | We support Option 1. |
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| **Scheduled PRBs:**   * Option 1: 48 * Option 2: other values | CATT | Should be aligned with the bandwidth assumption of PDSCH. |
| ZTE | This can be derived by AL and number of symbols of CORESET. |
| NTT DOCOMO | Option 1 is fine, and in this case AL of 16 may be reasonable. |
| **Other parameters** | CATT | At least the following parameters should be clarified:  Mapping type, REG bundle size, wide-band RS or not. |
| ZTE | The BLER target is 1%. Interleaved mapping. |
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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) | Samsung | B4 with 60khz |
| ZTE | Option 1 |
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| **Scheduled PRBs:**   * Option 1: 12 * Option 2: other values | Samsung | Option 1 for 12PRB expressed in number of PRBs for PUSCH with 60kHz |
| ZTE | Option 1 |
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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 | Samsung | Option3 |
| ZTE | Option 3 |
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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. |
| Samsung | The link budget template for FR2 is the same as FR1. |
| ZTE | Choosing from above two options, we slightly prefer Option 1-1. |
| NTT DOCOMO | We prefer to follow FR1. |

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. |
| Samsung | In eMBB with low data rate and VoIP, we prefer to apply HARQ retransmission and hence HARQ gain for data channel in template is changed for the each service such as 0.5 for eMBB with high data rate and 0 for eMBB with low data rate and VoIP. |
| ZTE | We are fine with above template. |
| NTT DOCOMO | We prefer to follow FR1 for the template. And we think Tx power for BS and UE is the most essential parameter for the link budget, since they are directly related to the performance difference between DL and UL (and Tx power difference among companies are large, e.g. more than 10 dB). |
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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** |
| Samsung | We prefer Option 1 |
| ZTE | Option 1 |
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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** |
| Samsung | We prefer Option 1 |
| ZTE | Similar to FR1, we are not sure how to model this accurately for different channels. That’s one reason we suggest SLS based method. We are glad to see proposals based on Option 2. |
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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** |
| Samsung | We prefer Option 1 |
| ZTE | Similar to FR1, we are not sure how to model this accurately. That’s one reason we suggest SLS based method. We are glad to see proposals based on Option 2. |
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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** |
| Samsung | We prefer Option 1 |
| ZTE | Similar to FR1, we are not sure how to model this accurately. That’s one reason we suggest SLS based method. We are glad to see proposals based on Option 2. |
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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** |
| Samsung | We prefer Option 1 |
| ZTE | Option 1 |
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| **Lognormal shadow fading std deviation for control channel** | ZTE | The models in TS 38.901 can be used.  Indoor: 8.03 dB for NLOS  Urban: 6 dB for NLOS  Suburban: 7.82 dB for NLOS |
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| **Shadow fading margin for control channel** | ZTE | A function of the cell area reliability and log-normal function with std deviation above. |
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| **Lognormal shadow fading std deviation for data channel** | ZTE | The same as control channel. |
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| **Shadow fading margin for data channel** | ZTE | The same as control channel. |
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| **Penetration margin** | Samsung | In TR 38.900, there are the equations for penetration loss in terms of the carrier frequency and channel model. We can calculate the penetration margin based on the equation especially for FR2. |
| ZTE | Penetration margin is frequency dependent. We suggest using the model in TS 38.901. More specifically,   * For O2I: Both low-loss and high-loss models are considered to urban scenario, and only the low-loss model is considered to rural scenario, according to Table 7.4.3-2 of TS 38.901. * For O2O: Car penetration loss is used, following distribution  with *μ* = 9, and σ*P* = 5. |
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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** |
| NTT DOCOMO | We prefer to follow FR1 for the template. |
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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 | Samsung | 56bits, 60khz (optional 120khz), 2PRBs, 2DMRS OS, |
| ZTE | TBS of 144 bits and 10%rBLER are assumed as defined in TS 36.824. Other parameters follow that of PUSCH. |
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| SSB/PBCH | ZTE | A combination of 4 SSBs in 80 ms is assumed |
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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 |
| Samsung | The Target performance metric for FR2 is the same as FR1. We support the use of the ISD target, but we also agree to further discuss the performance target for different scenarios (different data rate targets, channel conditions, etc.). If we additionally consider the MCL used in 36.824 in terms of the evaluation methodology, it can be used an MCL target for the target performance, and the balance of DL and UL channels or comparison between LTE and NR can be done in terms of MCL. It should not be additional burden for target performance. |
| ZTE | Similar to FR1, our first preference is to use system-level simulation to obtain the target performance, (i.e. the 5th percentile downlink or uplink SINR value in CDF curve).  We are also ok with Option 1 or Option 2 if we can define an appropriate target ISD or target MCL.  In addition, we are not sure whether the bottleneck channels would be much different between FR1 and FR2. So, another alternative is we don’t set a target for FR2 while only identify the bottleneck channels. The overall target for enhancement is the same for both FR1 and FR2. |
| NTT DOCOMO | We prefer to follow FR1. |

# References

1. RP-193240, China Telecom, New SID on NR coverage enhancement, 3GPP TSG RAN Meeting #86, Sitges, Spain, December 9th – 12th, 2019.
2. 3GPP TR 37.910, “Study on self evaluation towards IMT-2020 submission”, September, 2019.
3. ITU-M.2412, “Guidelines for evaluation of radio interface technologies for IMT-2020”.
4. R1-2003299 Baseline coverage performance for FR2 Huawei, HiSilicon
5. R1-2003339 Discussion on baseline coverage performance for FR2 ZTE
6. R1-2003436 Evaluation on NR coverage performance for FR2 vivo
7. R1-2003650 Discussion on the baseline performance and simulation assumptions of coverage enhancement for FR2 CATT
8. R1-2003774 Discussion on baseline coverage performance for FR2 Intel Corporation
9. R1-2003779 Downlink coverage in FR2 Charter Communications, Inc
10. R1-2003915 Scenarios and simulation assumptions for coverage enhancement in FR2 Samsung
11. R1-2003971 Discussion on coverage enhancements in FR2 CMCC
12. R1-2004179 Baseline coverage evaluation of UL and DL channels – FR2 Nokia, Nokia Shanghai Bell
13. R1-2004197 Considerations on Simulation Assumptions for Coverage Enhancements for FR2 Sony
14. R1-2004305 Simulation assumptions for UL in FR2 InterDigital, Inc.
15. R1-2004353 Simulation Parameters and Initial Results for FR2 Ericsson
16. R1-2004425 Baseline coverage performance for FR2 NTT DOCOMO, INC
17. R1-2004498 Baseline FR2 coverage performance Qualcomm Incorporated

# Appendix