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.  |
| Nokia/NSB | We are fine to confirm the target throughput identified in SID for FR2. We are also open to consider other values, especially for Urban. In fact, we would like to note that since the UL throughout targets for Urban and Indoor are the same. However, propagation conditions significantly differ between the two scenarios. If the throughput targets are the same, then RAN1 should agree to include at least one “UL-heavy” frame structure for the Urban scenarios, e.g., 3D1S6U (10D:2G:2U). |
| Qualcomm | Considering the large imbalance of link budget between UL and DL data, we are open to also consider a lower target UL data rate for 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. |
| Nokia/NSB | We support the proposal. Furthermore, it may be wiser to first agree on the codec, e.g., AMR or EVS, and then agree on TBS. Having said this, we propose to discuss VoIP parameterization in 8.4.1.1, given that VoIP is not prioritized for FR2. |
| Qualcomm | Support |

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. |
| Nokia/NSB | We support the proposal. |
| Qualcomm | We agree with the proposal and option 1 (link-level simulation) |

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. |
| Nokia/NSB | We considered Option1 in our paper since 30GHz is typical value used for IMT2020 self-evaluation. However, we are open to support Option 2 as second preference. |
| Qualcomm | We prefer option 2 (28GHz) |
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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. |
| Nokia/NSB | We support Option 1, however we would like RAN1 to consider two frame structures for the FR2 study. As discussed above, and in the frame structure selection for FR1, we observe that “UL-heavy” frame structure selection can offer better coverage. These types of configuration are supported in NR and should be considered, at least as a benchmark. Therefore, we propose to add 3D1S6U (10D:2G:2U) in the list of considered frame structure for evaluation in FR2. |
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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. |
| Nokia/NSB | We support option 1. We note that Indoor scenario must consider 120kHz SCS and we should consider the same SCS for all scenarios in FR2. |
| Qualcomm | We support option 1 |
| **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. |
| Nokia/NSB | Option 1. Same definition as FR1. |
| **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. |
| Nokia/NSB | Low speed UEs should move at 3 Km/h for both outdoor and indoor in all scenarios. Outdoor high speed UEs can move with 30 Km/h and 120 Km/h or Urban and Suburban, respectively.  |
| Qualcomm | We recommend considering both 3km/h and 30km/h for Urban outdoor |
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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. |
| Nokia/NSB | Number of receive AE: Our preference is wrongly captured. For indoor we prefer 128, i.e., Option 2. However, we are open to considered different number of AEs, if they not exceed the maximum value noted in ITU-R M.2412-0 for IMT-2020 self-evaluation for respective scenarios.Number of receive TxRU: Option 1. |
| Qualcomm | We prefer 256 antennas per polarization for both Rural and Urban.Number of receive TxRUs for BS: 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. |
| Nokia/NSB | Number of receive AE: We are open to discuss on different number of AEs. However, those number should not exceed the maximum value noted in ITU-R M.2412-0 for IMT-2020 self-evaluation for respective scenarios.Number of receive TxRU: It is not clear to us why both DL and UL setting is considered for the number of receive TxRU, which seems a DL parameter to us. If the Moderator was indeed focusing only on the number of receive TxRUs for UE, then our preference is 2 TxRUs. Conversely, if the intention was to capture the preference for number of TxRUs for DL and UL, then we prefer Option 1 for DL and Option 2 for UL. |
| Qualcomm | We prefer 4 antennas per polarization for the UE. Also, we prefer option 1 for UE TxRU (2 ports for both cases of UL and DL)  |
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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. |
| Nokia/NSB | Our preference was wrongly captured. Our preferences are as follows:* Indoor: TDL-A 26ns for both NLOS and LOS.
* Urban: TDL-C 263ns for both NLOS and LOS.

Suburban: TDL-C 37ns for both NLOS and LOS. We agree with the comment made by CATT. |
| Qualcomm | We prefer CDL |
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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 PRBsSuburban: 1 PRBFor 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). |
| Nokia/NSB | We think that it is relevant to consider 200MHz channel bandwidth for all scenarios (i.e., 132 PRBs for 120kHz SCS).We share ZTE’s opinion on the criterion which should be used to choose the number of allocated PRBs (and corresponding MCS) for PUSCH. We think it would be technically more appropriate to choose the combination which yields the best performance. The scope of this SI is to assess the coverage of the considered channels to identify possible bottlenecks and study improvements, whenever applicable. RAN1 cannot claim that a channel, e.g., PUSCH, is a coverage bottleneck if its considered baseline performance is lower than what can be achieved according to Rel-15 and Rel-16, when coverage maximization is the target. In this sense, we cannot accept to select a fixed number of PRBs if clearly sub-optimal for coverage evaluations.  |
| Qualcomm | We prefer DL bandwidth to be 100MHz. However, bandwidth for UL data may depend on the rate. |
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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. |
| Nokia/NSB | Option 1. However, as also discussed for FR1, the optimal MCS/number of PRBs couple that provides the “best coverage”, while guaranteeing that a valid TBS is obtained, should be considered. We do not agree to fix a number of PRBs without proper evaluation, as discussed earlier. Similarly, we do not agree to fix an MCS index without proper evaluation. The target throughput values have been clearly defined for each scenario, the lowest MCS that satisfies the target throughput for a given number of PRBs should then be selected. The corresponding TBS would then be straightforward to find. In this context, the lowest considered code rate for PUSCH cannot be 1/3 in our view, i.e., MCS4 of Table 5.1.3.1-1, and the number of PRBs allocated to PUSCH should not be fixed prior to discussing MCS constructively. This would really go against the interest and the scope of the SI, both for eMBB and VoNR services. |
| Qualcomm | Option 1 is preferred |
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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. |
| Nokia/NSB | Similar scheme/value for FR1 should be applied for FR2. |
| **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. |
| Nokia/NSB | Intra-slot FH hopping for PUSCH (open to discuss if assuming 1 or 2 DMRS per slot).No FH for PDSCH. |
| **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. |
| Nokia/NSB | Similar scheme/value for FR1 should be applied for FR2. |
| **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. |
| Nokia/NSB | Similar scheme/value for FR1 should be applied for FR2. |
| **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. |
| Qualcomm | The number of SSB beams and the gain differential between broadcast and unicast beams needs to be specified, because this is a main determining factor in the performance of PRACH. |
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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. |
| Nokia/NSB | Similar scheme/value for FR1 should be applied for FR2. In this context, we prefer to consider only one UCI payload size for PUCCH F3. Both 20 and 22 bits would be good values for us. |
| Qualcomm | We think PUCCH format 1 with 2 bits should be also considered (option 2). For larger payloads, format 3 with 11 bits (L1 report for 1 beam among 16 beams) and 21-bits UCI size, before CRC (L1 report for two beams among 32 beams) should be evaluated. |
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| **Scheduled PRBs:** * Option 1: 1
* Option 2: other values
 | ZTE | We support Option 1 |
| Nokia/NSB | Similar scheme/value for FR1 should be applied for FR2. |
| Qualcomm | 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. |
| Nokia/NSB | A DCI size of 64 bits (40 +24 CRC bits) with AL = 16 is our preference. Concerning the latter parameter, we think the most suitable configuration for coverage maximization should be preferred, i.e., AL=16. This would yield a more sensible benchmark, and perfectly supported by specification. We have no preference for the format. |
| Qualcomm | We think 40-bit DCI should be considered as the baseline. DCI payload = 40bits + CRC= 64 bits. We are open to both AL=8 and AL=16. |
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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. |
| Qualcomm | Option 1 |
| Nokia/NSB | Option 1. |
| **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.  |
| Nokia/NSB | 48 PRBs for CORESET bandwidth, but full channel bandwidth should be considered for noise power calculation. |
| **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.  |
| Qualcomm | The number of SSB beams and the gain differential between broadcast and unicast beams needs to be specified, because this is the main determining factor in the performance of broadcast channels and RACH. For example, in the case of PDCCH, performance of Msg2 PDCCH is very much dependent on the number of SSB beams and their gain (rather than the total number of gNB antennas).  |
|  |  |

* 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.

|  |  |  |
| --- | --- | --- |
| **Format type** * Option 1: Format B4

(Intel, Ericsson, Qualcomm, vivo)* Option 2: Format C2

(CMCC, Huawei, HiSilicon) | Samsung  | B4 with 60khz |
| ZTE | Option 1 |
| Nokia/NSB | Option 2. |
| Qualcomm | Option 1 |
| **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 |
|  |  |
| **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 |
| Qualcomm | Option 3 |
|  |  |
| **Other parameters** | Qualcomm | The number of SSB beams and the gain differential between broadcast and unicast beams needs to be specified, because this is a main determining factor in the performance of PRACH. |
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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.

|  |  |
| --- | --- |
| **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. |
| Nokia/NSB | Option 1-1 is our preference. However, we understand the concerns some companies have expressed in this regard. In principle, we do not see a big problem in including MCL in the performance tables if this can help reaching an agreement. After all, MPL cannot be calculated without calculating MCL first (either implicitly or explicitly). Therefore, we propose to add one row to calculate MCL in IMT-2020 self-evaluation template and merge two tables below into only a single table that outputs both MPL and MCL. |
| Qualcomm | We think MCL approach is more appropriate for comparing link budget of different channels, without going to the details of all the parameters for the IMT2020 approach |

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

|  |  |
| --- | --- |
| **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). |
| Nokia/NSB | We agree with CATT. Additionally, and as aforementioned, we are open to add one row to calculate MCL in IMT-2020 self-evaluation template and merge two tables below into only a single table that outputs both MPL and MCL. Finally, we would like to restate what we stated for FR1 about the different cell area reliability value assumed for control and data channel. Is this really necessary, given that different reliability of the channels is already captured by different BLER requirements to calculate SINR? |

Companies are encouraged to provide views on the parameters with TBD in Table E.

|  |  |  |
| --- | --- | --- |
| **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 |
| Nokia/NSB | 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. |
| Nokia/NSB | Option 1 |
|  |  |
|  |  |
| **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. |
| Nokia/NSB | Option 1 |
|  |  |
|  |  |
| **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. |
| Nokia/NSB | Option 1 |
|  |  |
|  |  |
| **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 |
| Nokia/NSB | 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 NLOSUrban: 6 dB for NLOSSuburban: 7.82 dB for NLOS |
| Nokia/NSB | Follow the respective path loss models presented in Tables A1-2 and A1-3 in ITU-R M.2412-0 “Guidelines for evaluation of radio interface technologies for IMT-2020”.The shadow fading standard deviations for respective scenarios are:* Urban/Suburban: 6 dB for NLOS and 4 dB for LOS.
* Indoor: 8.03 dB for NLOS and 3 dB for LOS.

The corresponding slopes of PL models are:* Urban/Suburban: 39.08 for NLOS and 40 for LOS.
* Indoor: 38.3 for NLOS and 17.3 for LOS.
 |
|  |  |
| **Shadow fading margin for control channel** | ZTE | A function of the cell area reliability and log-normal function with std deviation above. |
| Nokia/NSB | The slope of PL model and shadow fading standard deviation $σ\_{SF}$ should be aligned first. The shadow fading margin can then be calculated based on the slope, standard deviation and cell area reliability requirement.In IMT-2020 self-evaluation, the effective fading standard deviation ($σ\_{e}$) is assumed for the calculation of SF margin, where$$σ\_{e}= \sqrt{σ\_{SF}^{2}+σ\_{P}^{2}} ,$$and $σ\_{P}$ is the penetration loss standard deviation. * For in car scenario, $σ\_{P}=5$ dB in both FR1 and FR2.
* For O2I scenario, $σ\_{P}=0$ dB in FR1. In FR2, there are two penetration loss models for O2I, $σ\_{P}=4.4$ dB and $σ\_{P}=6.5$ dB for low-loss and high-loss models, respectively.

Therefore, to find $σ\_{e}$ for the calculation of SF margin for Urban/Suburban O2I in FR2, we can consider:* Option 1: Use $σ\_{P}$ of low-loss model.
* Option 2:
	+ Step 1: Find $σ\_{e,low}$ by $σ\_{P}$ of low-loss model and $σ\_{e,high}$ by $σ\_{P}$ of high-loss model.
	+ Step 2: Find SFlow and SFhigh using $σ\_{e,low}$ and $σ\_{e,high}$, respectively.
	+ Step 3: SF margin = 80% SFlow + 20% SFhigh, similar to the calculation of penetration loss as noted in Table 5 of ITU-R M.2412-0 for Urban.
 |
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| **Lognormal shadow fading std deviation for data channel** | ZTE | The same as control channel.  |
| Nokia/NSB | Shadow fading standard deviation should be the same for both data and control channel. Please see our comment for control channel above. |
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|  |  |
| **Shadow fading margin for data channel** | ZTE | The same as control channel.  |
| Nokia/NSB | Please see our comment for control channel above. |
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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.
 |
| Nokia/NSB | We share the same view with ZTE. The formulas in Table A1-7 of ITU-R M.2412-0 (or Table 7.4.3-2 in TR 38.901) should be considered for penetration loss calculation in case of O2I. In case of O2O, formula for car penetration loss follows Section 3.3 in ITU-R M.2412-0 (or Section 7.4.3.2 in TR 38.901). |
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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. |
| Nokia/NSB | TBS of 56 bits (72 optional) |
| Qualcomm | We think at least the performance of 56-bit Msg3 should be included in the baseline evaluation. To have realistic assessment, the difference in the gain of unicast and broadcast beams should be considered. |
| SSB/PBCH | ZTE | A combination of 4 SSBs in 80 ms is assumed |
|  |  |
|  |  |
| Other channels | Qualcomm | It is important to include the performance of Msg2 PDCCH and RMSI PDCCH in the baseline performance evaluation. To have realistic assessment, the difference in the gain of unicast and broadcast beams should be considered. |
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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.

|  |  |
| --- | --- |
| **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. |
| Nokia/NSB | Similar to our comment for FR1, it would seem more reasonable to first agree/align on the EVM and simulation assumptions and then discuss performance targets. |
| Qualcomm | We think comparing MCL for different channels (and their relative performance) is more important and more useful than setting a target for ISD or MCL. Differences in MCL of different channels is much less dependent on exact values of common parameters (which can be quite arbitrary).  |

# References

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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