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. |
| Intel | We support the proposal and we are fine to remove the bracket. |
| SONY | Support. We also note that it may be challenging to support 5Mbps in the UL in the urban scenario. |
| Ericsson | We think 400 MHz system bandwidth should be used, since higher bandwidths are a primary advantage of FR2. Therefore, the data rates should be higher.  Indoor and Urban: DL: 100, 200 Mbps; UL: 10, 20 Mbps |
| InterDigital | We support the target data rate for the indoor scenario |

(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 |
| Intel | We support the proposal |
| SONY | Support. As per Samsung and ZTE’s comments, from a RAN1 perspective, the important point is to define a TBS and interarrival time. |
| Ericsson | Agree with the proposal. |
| InterDigital | We support the proposal. The corresponding TBS and arriving interval should also be agreed for better alignment in the evaluation assumptions. |

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) |
| Intel | Similar comment as for FR1. We support Option 1 and the proposal. |
| SONY | We basically support the proposal, but there will inevitably be differences in the evaluation methodology between FR1 and FR2. A significant difference is the need to consider the spatial properties of the channel / spherical coverage aspects.  To be more specific, the link budget should take into account the spatial properties of the channel when the UE is in a worst case (or X%-ile, e.g. X=5) orientation. This beamforming pattern / spatial aspect can be derived from considering random UE orientations and channel realizations. and calculating the X%-ile antenna gain. We don’t classify this as a full-blown system simulation. |
| Ericsson | Our view is that both link budget based analyses and system level simulations should be able to be presented. We think the compromise proposal made for FR1 that reports both maximum coupling loss and maximum isotropic loss (a.k.a ‘hardware link budget’) can be used for the link budget based analyses in FR2 as well as FR1. System level simulations are even more important for FR2, since RAN1 has less experience with FR2 evaluation.  **We suggest to discuss scenarios and channel setups, as this is needed to define many of the parameters. Please find more details on scenarios and channel setups in Appendix A1.** |
| InterDigital | We support the proposal while we are open to discussion for details in each step in the proposal. |

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) |
| Intel | We prefer Option 2, but we are open to consider Option 1. |
| SONY | We are OK with any of these options as we think that the specific frequency chosen would minimally impact the evaluation results. |
| Ericsson | Option 1. While the exact frequency is not critical, a single should be all that’s needed, and 30 GHz was used in prior evaluations. |
| **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. |
| Intel | We are fine with option 1. |
| SONY | We prefer option 1 or 3. We also have sympathy with the views of Nokia. |
| Ericsson | 3:1 ratio seems sufficient to us. |
| InterDigital | For frame structure, referring to TR 36.284, we propose DDSUU since 2 out of 5 slots are reserved for UL in TR 36.824. We are also open to considering a frame structure that maximizes performance in both DL and UL. |
| **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 |
| Intel | We prefer Option 2, but we are open to consider option 1. |
| SONY | Option 1 |
| Ericsson | Option 1; 120 kHz should be enough for evaluation |
| **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. |
| Intel | Same metric as in FR1. |
| SONY | Option 1 as a baseline. Companies can also simulate with a higher initial BLER target and apply HARQ re-transmissions to achieve a lower final BLER |
| Ericsson | Depends on the channel setup; see details below and in Appendix A1 |
| InterDigital | We support Option 1; rBLER=2% and BLER=10% for VoIP and eMBB, respectively. |
| **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 |
| Intel | We prefer for indoor, 3km/h and for outdoor, 30km/h. |
| SONY | For indoor we support 3 km/h makes. For outdoor both 30 km/h and 120 km/h can be studied for all scenarios. |
| Ericsson | For urban, prefer to start with 3 kmph, and later consider higher speeds e.g. 30 kmph. |
| InterDigital | We support to include 3km/h for outdoor scenarios. As Option 3, we propose to include 3km/hr for outdoor on top of 30km/hr and 120km/hr for urban and suburban scenario, respectively |
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| **Number of receive antenna elements for BS:**  Indoor:   * 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 |
| Intel | For number of antenna elements for BS:   * We are fine for Option 1 (256) for all different scenarios.   For number of TxRUs at BS:   * We support Option 1. |
| SONY | No strong opinion on the number of elements, but we assume the BS supports two polarizations. |
| Ericsson | Indoor deployments will use smaller arrays.  OK to start with 2T2R for gNB to model the analog case. Higher numbers of TXRUs should not be precluded at this stage. |
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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) |
| Intel | For number of Rx antenna elements for UE:   * We are fine with Option 3 (4) or 8 for all different scenarios.   For number of TxRUs at UE:   * For DL, we support Option 1. * For UL, we support Option 2. |
| SONY | Option 1: We assume 4 elements per antenna panel. Both dual polarized and single polarized antenna panel should be taken into account. The effect of number of antenna panels and their orientation should be studied as well.  2 TxRUs is a reasonable assumption for both UL and DL, but needs to be associated with antenna panels in case there are any limitations. |
| Ericsson | Clarification: UE can have 8 dual polarized antenna pairs per panel in 2 panels with panel selection and time domain beamforming per polarization with 1T2R |
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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 |
| Intel | For channel model, we assume TDL-A for FR2.  We support Option 1. |
| SONY | Option 2 in all cases. We favor LLS with CDL channel models in all the simulations for FR2. |
| Ericsson | If one delay spread is used in link simulation, prefer 100 ns. If more than one delay spread is used, 30 and 300ns are preferred.  Medium correlation should be used for the TDL models.  TDL models should be sufficient, since beamforming performance is the more critical issue, and this should be addressed with system level simulation. |
| InterDigital | We support use of CDL for evaluation. CDL-A with DS=43ns for indoor, and CDL C with DS=616ns for urban. We should also agree on the antenna type (e.g., omni-directdional, 2D Gaussian) and desired mean angle range for better alignment in the evaluation assumptions |
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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). |
| 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. |
| Intel | We assume 100MHz as occupied channel bandwidth for DL. The number of PRBs depends on the channel bandwidth and SCS.  For UL, occupied channel bandwidth is the actual bandwidth for uplink transmission. |
| SONY | As per comments from other companies, the coverage can depend on the occupied channel bandwidth. Given that lower coding rates may be associated with better coverage, we would be looking towards bandwidths aligned with options 1, 3 or 4. |
| Ericsson | Clarification: We prefer a system bandwidth of 400 MHz, but 100 MHz is used in the link simulations. Also, the Urban scenario uses 4 panels, where each panel takes 1/4 of the system bandwidth. |
| InterDigital | Similar to our comment for FR1 evaluation, for baseline performance, it is important to agree on the optimum combination of parameters such as # of PRB, TBS, SCS, # of repetitions and MCS for maximum coverage performance and better alignment of the results among the companies. |
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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 |
| Intel | Option 1.  We would like to consider aligned simulation assumptions, especially TBS/MCS and the number of PRBs/symbols among companies to conduct meaningful study. |
| SONY | These parameters should be “TBI” by the proponent. Some companies might favour a larger number of PRBs to improve coding gain, while others might want fewer PRBs to increase PSD. Similarly for TBS / MCS, some companies might favour a smaller TBS and a lower MCS while others favour a larger TBS, higher MCS and more HARQ re-transmission. Basically, in some ways, the choice of number of PRBs, TBS and MCS is part of the coverage enhancement scheme. |
| Ericsson | Option 1, with adaptive selection of TBS and MCS: throughput is mapped to a desired SINR for data channels, while control channels have fixed parameters according to the tables in Appendix A1. |
| InterDigital | Option 1, this should be considered jointly with the number of PRB. |
| **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. |
| Intel | For VoIP, repetitions can be considered. For eMBB, repetition may not be assumed. |
| SONY | Repetition of up to REP8 can be considered.  The amount of repetition applied can be up to the proponent. Proponents might want to trade off lower MCS for repetition, so the number of PUSCH repetitions should be dependent on the proposal. |
| Ericsson | 2, 4, or 8 can be considered in general according to Rel-15/16  TBD: if VoIP repetition is used. |
| InterDigital | As we commented earlier, the number of repetitions should be considered jointly with parameters such as # of PRB, TBS, SCS and MCS for maximum coverage performance and better alignment of the results among the companies. |
| **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. |
| Intel | For PUSCH, we assume DFT-s-OFDM waveform. Further, intra-slot frequency hopping is enabled.  For PDSCH, we assume CP-OFDM waveform. Further, distributed mapping is assumed. |
| SONY | Frequency hopping may be applied, at least for PUSCH. |
| Ericsson | See comments with respect to PUCCH below and details in Appendix A1 |
| InterDigital | Frequency hopping can be turned on with inter-slot FH |
| **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. |
| Intel | Follow decision in FR1 |
| SONY | HARQ improves coverage, so should be considered in the baseline. Up to [4] retransmissions for PUSCH and PUCCH. The physical resources for re-transmission can be different to the resources for initial transmission. |
| Ericsson | Up to 8 attempts (similar to max number of repetitions); frequency allocation varies/hops with HARQ. Different max number of attempts can be considered according to data carried / QoS.  Please see detailed proposals for channel configurations in Appendix A1 |
| InterDigital | For eMBB, we can use up to the maximum value for the number of HARQ processes since there is no latency requirement. The number of HARQ processes for VoIP in FR2 should be considered jointly with SCS. |
| **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. |
| Intel | 1 or 2 DMRS symbols depending on UE speed.  For 3km/h, 1 front loaded DMRS can be assumed.  For 30km/h, 2 DMRS symbols can be assumed. |
| SONY | Different DMRS densities can be considered including 1DMRS and 2DMRS |
| Ericsson | We think at least 3 DMRS symbols should be used for PUSCH. Agree that UL data should not be multiplexed with UL DMRS. DMRS for PUCCH is given below.  For PDSCH, 2 DMRS symbols are used for data and 3 are used for Msg2.  Details are in Appendix A1 |
| InterDigital | The optimum number of DMRS symbols should be agreed. We propose to use 2 DMRS symbols for PUSCH per slot. We are also open to other values (greater than 2) for the number of DMRS 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. |
| 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. |
| Ericsson | For waveform: DL: OFDM, UL: DFT-S-OFDM  Our detailed proposals for channel configurations are in Appendix A1 |
| InterDigital | For UL, we support to use DFTsOFDM for PUSCH. In industrial/commercial applications, coverage enhancement for UL OFDM may also be needed since OFDM allows flexible multiplexing. To maximize applicability of the study, we are open to discussion for UL OFDM in the evaluation as well. |

* 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.

|  |  |  |
| --- | --- | --- |
| **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. |
| Intel | For Format 1, we prefer option 1, but we are open to consider option 2.  For Format 3, we prefer option 3, but we are fine with Option 2.  We suggest not to consider format 2 for coverage analysis as format 2 is not targeted for coverage enhancement. |
| Ericsson | **Format 3 with 4 bits Ack/Nack**:  PUCCH Format 3 using 14 symbols, 1 PRB, 4 DMRS and frequency hopping  4 bits payload for ACK/NACKS (three bits for 3DL:1UL TDD asymmetry and another bit for scheduling request)  Pr(DTX to ACK) <=1%, Pr(NACK to ACK) <=0.1%,  Pr(ACK error) <=1% or 10%  **CSI on PUCCH format 3 or PUSCH:**  Type I wideband CSI feedback  - 8+2=10 bits for 2 port feedback + 3bit CRI  1 PRB, no HARQ ACK/NACKs  - PUCCH format 3 with 4 DMRS, with frequency hopping, or  - PUSCH without multiplexing with data on PUSCH and no frequency hopping |
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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 |
| Intel | We prefer Option 1.  We assume the number of symbols as 14 for PUCCH. |
| Ericsson | Option 1 is fine for PUCCH and CSI on PUSCH |
|  |  |
| **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% |
| Ericsson | CSI on PUSCH should be considered, as commented above and in Appendix A1 |
|  |  |
|  |  |

* 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.

|  |  |  |
| --- | --- | --- |
| **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. |
| Intel | For DCI size, we support 40 bits and AL of 4 or 8.  We assume fallback DCI format. |
| Ericsson | PDCCH using aggregation level 16 and DCI format 0\_0 or 1\_0 with payload of 40bits+24bits CRC  CORESET 66 PRBs, 1 symbol, non-interleaved mapping,  precoder cycling |
|  |  |
|  |  |
| **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. |
| Intel | Option 1 |
| Ericsson | Option 2: 1 symbol |
|  |  |
| **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. |
| Intel | Scheduled PRBs depends on the AL and the number of symbols for CORESET.  We would assume this is for CORESET size in frequency, which is 48 PRBs in our simulations. |
| Ericsson | Link and rank adaption based on 20 slot 2 port wideband CSI feedback periodicity and HARQ with up to three retransmissions.  66 PRBs, 2 symbols with DMRS, PDSCH and DMRS mapped to 13 symbols (1 symbol reserved for PDCCH),  overhead due to CSI-RS and TRS with 20ms period |
|  |  |
| **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). |
| Intel | We also need to consider 1) whether narrowband or wideband DMRS, 2) interleaved or non-interleaved CCE-to-REG mapping is assumed |
| Ericsson | See detailed channel parameters in Appendix A1 |
|  |  |

* 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 |
| Intel | Option 1 |
| Ericsson | Option 1: If the maximum PRACH coverage is to be evaluated, the longest format should be used. |
|  |  |
| **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 |
| Intel | Option 1. We assume same SCS for PUSCH/PUCCH. |
| Ericsson | 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 |
| Intel | Option 3. |
| Ericsson | 10% or 1% missed detection at 0.1% false alarm probability |
|  |  |
| **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. |
| Ericsson | Maximum timing estimation error 50% of the normal CP length  64 preambles per cell  Initial timing offset uniformly distributed in [0, 0.77 µs] for an ISD of 200m |
|  |  |
|  |  |

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 |
| Intel | For FR2, we slightly prefer Option 2 for coverage analysis.  The reason is that some of the parameters for link budget template in IMT-2020 submission are missing. It would take time to converge on some of the values. Given the limited time for study, we would suggest to consider MCL for coverage analysis in FR2.  In our view, hardware link budget (23a and 23b) from IMT-2020 link budget template can be considered as a starting point for MCL analysis. |
| SONY | Option 1-1. We think it is important to take the spherical coverage of UE into account in the link budget calculation. In this sense, Option 1-1 is a better fit. To capture the spherical coverage, we propose that a UE with multiple panels is dropped with a random orientation in a system, and the X-th percentile antenna gain is computed. Companies need to agree on X. |
| Ericsson | Considering these two options, we prefer to merge options 1-1 and 1-2 by using a version of the approach in 36.824 where antenna gain is added to produce maximum isotropic loss (a.k.a hardware link budget in IMT-2020). This is discussed in more detail in the comments to Table E below. |
| InterDigital | We support to use MCL (Option 1-2) due to its compactness. It is sufficient for comparing different techniques. |

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.

|  |  |
| --- | --- |
| **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? |
| Intel | As mentioned above, we would like to consider hardware link budget (23a and 23b) in the above table as a starting point for MCL analysis.  Further, we would like to clarify the detailed deployment scenario in the template, especially ISD for rural and urban scenario. It is good to align the ISD for each deployment scenario so as to provide meaningful coverage analysis for different physical channels. |
| Sony | We are OK with using the proposal. To take the UE beamforming gain and spherical coverage into account, the full spherical AoA distribution should be taken into account. Based on commercial handsets on the market now, both single polarized and dual polarized UE antenna panels should be taken into account.  Inclusion of spherical coverage will influence the parameters (4) and (11) (the UE antenna gain. Simulations of spatial properties will give a gain distribution that includes both gain variations and the associated polarization properties. We propose that as an alternative to a fixed antenna gain for (4), (11), the X-th percentile derived from dropping a UE with a random orientation in the channel is used in the link budget.  We are OK with most reasonable values for the “TBD” values in the link budget (where values proposed at the time we edited this document seem reasonable). |
| Ericsson | The template has the merit of explicitly including key parameters like antenna gain and interference margin seems more complicated for the purpose of evaluating a link budget and determining bottleneck channels. We propose something closer to the ‘classical’ link budget of 38.913 and 36.864, but that uses the calculation of hardware link budget (rows 23a and 23b) from the IMT 2020 template. The detailed parameters like HARQ gain, boosting, etc., can be built into the required SINR, while other needed parameters are defined by the scenario. See Appendix A1 for detailed values.  Maximum Loss Calculation Template   |  |  | | --- | --- | | Physical channel name | Value | | Transmitter |  | | (1) Tx power  (dBm) |  | | Receiver |  | | (2) Thermal noise density (dBm/Hz) |  | | (3) Receiver noise figure (dB) |  | | (4) Interference margin (dB) |  | | (5) Occupied channel bandwidth (Hz) |  | | (6) Effective noise power           = (2) + (3) + (4) + 10 log(5)  (dBm) |  | | (7) Required SINR (dB) |  | | (8) Receiver sensitivity           = (6) + (7) (dBm) |  | | (9) MaxCL           = (1) - (8) (dB) |  | | (10) Antenna Gain |  | | (11) Maximum isotropic loss (a.k.a. ‘Hardware link budget’) = (9)+(10) |  | |

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 |
| Intel | Option 1 |
| Ericsson | Should be built into antenna element gain; see ‘Others’ below. |
|  |  |
| **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 |
| Intel | Option 1 |
| Ericsson | We propose option 2 is used when system simulations are not used. Option 2 should be based on statistics derived at the system level. |
|  |  |
| **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 |
| Intel | Option 1 |
| Ericsson | Interference margin should be based on statistics derived at the system level from the agreed scenarios. |
|  |  |
| **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 |
| Intel | Option 1 |
| Ericsson | Interference margin should be based on statistics derived at the system level from the agreed scenarios. |
|  |  |
| **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 |
| Intel | Option 1 |
| Ericsson | Should be built into antenna element gain; see ‘Others’ below. |
|  |  |
| **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 |
| 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. |
| Ericsson | Should be according to the agreed scenarios |
|  |  |
| **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 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 () is assumed for the calculation of SF margin, where  and is the penetration loss standard deviation.   * For in car scenario, dB in both FR1 and FR2. * For O2I scenario, dB in FR1. In FR2, there are two penetration loss models for O2I, dB and dB for low-loss and high-loss models, respectively.   Therefore, to find for the calculation of SF margin for Urban/Suburban O2I in FR2, we can consider:   * Option 1: Use of low-loss model. * Option 2:   + Step 1: Find by of low-loss model and by of high-loss model.   + Step 2: Find SFlow and SFhigh using and , 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. |
| Ericsson | Should be based on statistics derived at the system level from the agreed scenarios |
|  |  |
|  |  |
| **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. |
| Ericsson | Should be according to the agreed scenarios |
|  |  |
|  |  |
| **Shadow fading margin for data channel** | ZTE | The same as control channel. |
| Nokia/NSB | Please see our comment for control channel above. |
| Ericsson | Should be based on statistics derived at the system level from the agreed scenarios |
|  |  |
|  |  |
| **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). |
| Ericsson | Should be based on statistics derived at the system level from the agreed scenarios |
|  |  |
| **Other parameters** | Ericsson | gNB Element gain (with losses built in): Indoor: 5 dBi; Outdoor: 8 dBi  Indoor gNB Tx power: 23 dBm PA  Urban gNB Tx power: 40 dBm PA  UE: 9 dBm TRP, 23 dBm EIRP  gNB Noise Figure: 7 dB  UE Noise Figure: 10 dB  Detailed parameters and scenarios in Appendix A1 |
|  |  |
|  |  |
|  |  |

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.

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| NTT DOCOMO | We prefer to follow FR1 for the template. |
| Intel | As mentioned above, we would like to consider hardware link budget (23a and 23b) in the above table as a starting point for MCL analysis. This includes the MCL analysis in 36.824 with additional antenna gain, which is more appropriate for FR2 coverage analysis.  Further, in our view, for MCL based analysis, it is important to determine overall coverage enhancement target, which can be based on the worst coverage performance or other metric. Subsequently, the coverage gap for different physical channels can be identified accordingly. It is more appropriate to align the overall coverage enhancement target among companies. |
| Ericsson | We think this table is a good starting point, but is missing antenna gain. Therefore, we propose to add rows (10) and (11) as described above. |
| InterDigital | We propose to use the MCL table in TR 36.824 as the starting point. |
|  |  |

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.

|  |  |  |
| --- | --- | --- |
| **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. |
| Intel | TBS of 56 or 72 bits can be assumed. 1 or 2 PRBs with 14 symbols can be considered for Msg3 PUSCH simulations. |
| Ericsson | PUSCH with 7 bytes payload,  MCS 0, 2 PRBs, 3 DMRS symbols 11 symbols with PUSCH,  With 7 re-transmissions (8 attempts), using different frequency for different attempts. No PDCCH errors |
|  |  |
| SSB/PBCH | ZTE | A combination of 4 SSBs in 80 ms is assumed |
| Intel | 4 SSB combinations in TTI with 80ms. |
| Ericsson | SSBs are transmitted with 20ms periodicity  residual BLER after 4 retransmissions within MIB TTI of 80ms, UE is not assumed to know the SS/PBCH block index |
|  |  |
| 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. |
| Ericsson | **Msg2:**  PDSCH with 8 bytes payload,  MCS 0 with transport block scale factor 0.25, 12 PRBs,  3 DMRS symbol, 9 symbols with PDSCH (and 2 symbols reserved for PDCCH)  precoder cycling  **CSI on PUSCH:**  Type I wideband CSI feedback  - 8+2=10 bits for 2 port feedback + 3bit CRI  1 PRB, no HARQ ACK/NACKs  - PUSCH without multiplexing with data on PUSCH and no frequency hopping |
|  |  |

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). |
| Intel | It depends on which option (MCL or MPL) is considered for baseline coverage analysis. As mentioned above, for FR1, both options can be considered, but for FR2, it may be good to include the beamforming gain into the MCL analysis for coverage enhancement.  For Option 1, target ISD needs to be first clarified for coverage analysis. |
| SONY | Option 1 for FR2. Since spherical coverage issues, effectively impacting beamforming gain, are an issue at FR2, we think that a link budget target is more appropriate than an MCL target. |
| Ericsson | Our first preference is also to compare the coverage % of the different channel using SINR CDFs from system level simulation.  If link budget based analyses are used, the bottleneck channels should be determined by comparing the maximum loss including antenna gain and interference margin.  **So we propose option 3:**  **Option 3: Bottleneck channels are identified by selecting those that have the worst coverage, when antenna gain and interference are accounted for.** |
| InterDigital | We support Option 2. |

# 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: Scenarios and Channel Parameter Details

## A1 Proposal 1

**Table A1.1 Scenarios for 30 GHz**

|  |  |  |
| --- | --- | --- |
| Parameters | Indoor hotspot (30 GHz) | Dense Urban (30 GHz) |
| Layout | Indoor floor: (two three-sector sites with 60m ISD) | Hex. Grid |
| Inter-BS distance | 60m | 200m |
| Carrier frequency | 30GHz | 30GHz |
| Aggregated system  bandwidth | 30GHz: 400 MHz (DL+UL) | 30 GHz 400 MHz(DL+UL) |
| Simulation bandwidth | 400 MHz (TDD) | 30 GHz: 400 MHz (TDD); 100MHz/panel |
| Subcarrier spacing | 120 kHz | |
| TDD Pattern | 3DL:1UL | |
| Channel model | InH\_B from ITU M.2412 | UMa\_B from ITU M.2412 |
| BS Tx power | 23 dBm PA | 40 dBm PA |
| UE Tx power | 9 dBm TRP, 23 dBm EIRP | |
| BS antenna configurations & gain, including RF losses | Follow the modeling of ITU M.2412 | |
| AAS 128 antenna elements with (M,N,P,Mg,Ng) = (8,8,2,1,1)  2T2R for analog beamforming case; other values not precluded  23dBi total max gain  Antenna near the ceiling, panels in 3 sector configuration. | AAS 512 antenna elements in 4 panels with (M,N,P,Mg,Ng) = (8,8,2,2,2)  2T2R for analog beamforming case; other values not precluded  26dBi total max gain |
| Tilt: 3 deg | Tilt: 12 deg |
| BS antenna height | 3m | 25m |
| BS antenna element gain + connector loss | 5dBi | 8 dBi |
| BS receiver noise figure | 7 dB | |
| UE antenna configuration & gain, including RF losses | 1T2R, [2T2R]; (M,N,P) = (4,2,2); 2 panels in different directions | |
| UE antenna height | Follow the modeling of ITU M.2412 | |
| UE receiver noise figure | 10 dB | |
| Traffic model | Companies specify if full buffer or non full buffer is used when determining SINR statistics. | |
| Traffic load (Resource utilization) | See Table A1.2 | |
| UE distribution | 100% Indoor, 3km/h, | Uniform/macro TRP  - 80% indoor, 20% outdoor  - In case of outdoor (30km/h), penetration loss in-car is 9 dB (LN, σ = 5 dB).  Mix of O2I penetration loss models for higher carrier frequency  - Option1  - Low loss model – 80%  - High-loss model – 20% |

Table A1.2: Desired and interfering signal assumptions for 30GHz.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Channel** | **Desired signal beam** | **Interfering signal** | **Interferer activity** | **Power control SNR target** |
| **SSB** | GoB 4x16 | SSB | 1.0 |  |
| **Msg2 Pdcch** | GoB 4x16 | PDSCH | 0.5 |  |
| **Msg2 Pdsch** | GoB 4x16 | PDSCH | 0.5 |  |
| **PDCCH** | GoB 4x16 | PDSCH | 0.5 |  |
| **PDSCH data** | GoB 4x16 | PDSCH | 0.5 |  |
| **Msg 1 PRACH** | GoB 4x16 | PUSCH | 0.5 | 3dB |
| **PUCCH** | GoB 4x16 | PUCCH | 0.5 | 3dB |
| **Msg3 PUSCH** | GoB 4x16 | PUSCH | 0.5 | 10dB |
| **CSI PUSCH** | GoB 4x16 | PUSCH | 0.5 | 10dB |
| **PUSCH Data** | GoB 4x16 | PUSCH | 0.5 | 10dB |

Table A1.3 Link level assumptions and SNR requirements for different channels

|  |  |
| --- | --- |
| **Channel** | **Assumptions** |
| **Initial Access** | |
| SSB (P/S-SS and PBCH) | SSBs are transmitted with 20ms periodicity  residual BLER after 4 retransmissions within MIB TTI of 80ms, UE is not assumed to know the SS/PBCH block index  10%, 1% error rate |
| MSG1  (PRACH) | Format B4 with 12 symbols  10% or 1% missed detection at 0.1% false alarm probability, with maximum timing estimation error 50% of the normal CP length  64 preambles per cell Initial timing offset uniformly distributed in [0, 0.77 µs] for an ISD of 200m |
| MSG2 RAR (PDCCH+PDSCH) | PDSCH with 8 bytes payload,  MCS 0 with transport block scale factor 0.25, 12 PRBs,  3 DMRS symbol, 9 symbols with PDSCH (and 2 symbols reserved for PDCCH)  precoder cycling  10%, 1% error rate |
| MSG3 RRC request (PDCCH+PUSCH) | PUSCH with 7 bytes payload, MCS 0, 2 PRBs, 3 DMRS symbols 11 symbols with PUSCH,  With 7 re-transmissions (8 attempts), using different frequency for different attempts. No PDCCH errors  10%, 1% error rate |
| Uplink and Downlink Data Transmission | |
| DL assignment or UL Grant (PDCCH) | PDCCH using aggregation level 16 and DCI format 0\_0 or 1\_0 with payload of 40bits+24bits CRC  CORESET 66 PRBs, 1 symbol, non-interleaved mapping,  precoder cycling  10%, 1% error rate |
| DL data (PDSCH) | Link and rank adaption based on 20 slot 2 port wideband CSI feedback periodicity and HARQ with up to three retransmissions. 66 PRBs, 2 symbols with DMRS, PDSCH and DMRS mapped to 13 symbols (1 symbol reserved for PDCCH),  overhead due to CSI-RS and TRS with 20ms period  10% error rate |
| ACK/NACK  (PUCCH) | PUCCH Format 3 using 14 symbols, 1 PRB, 4 DMRS and frequency hopping  4 bits payload for ACK/NACKS (three bits for 3DL:1UL TDD asymmetry and another bit for scheduling request)  Pr(DTX to ACK) <=1%, Pr(NACK to ACK) <=0.1%,  Pr(ACK error) <=1% or 10% |
| CSI feedback (PUCCH or PUSCH) | Type I wideband CSI feedback   * 8+2=10 bits for 2 port feedback + 3bit CRI   1 PRB, no HARQ ACK/NACKs   * PUCCH format 3 with 4 DMRS, with frequency hopping, or * PUSCH without multiplexing with data on PUSCH and no frequency hopping   10%, 1% error rate |
| UL data (PUSCH) | Link and bandwidth adaption based on DMRS and HARQ with up to three retransmissions. Up to 66 PRBs, 2 symbols with DMRS, PDSCH and DMRS mapped to 14 symbols and no UCI overhead included  10% error rate |

## A2 Proposal 2