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

2.1.1 Target data rates for FR1

(1) eMBB

Based on SID, the target data rates for FR1 were identified:

* Urban scenario: DL 10Mbps, UL 1Mbps
* Rural scenario: DL 1Mbps, UL 100kbps

**Proposal:**

* **Adopt the following target data rates for eMBB performance evaluation for FR1.**
* **Urban scenario: DL 10Mbps, UL 1Mbps**
* **Rural scenario: DL 1Mbps, UL 100kbps**

Companies are invited to provide views on the above proposal.

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| **Companies** | **Comments** |
| ZTE | Support the proposal. |
| Nokia/NSB | Support the proposal. |
| Nomor Research GmbH | Nomor supports the proposal.  Target data rate values for eMBB are comprehensively discussed during the process of the SID. |
| Intel | Support the proposal. |
| Ericsson | For 700 MHz DL, both 1 and 2 Mbps, with 2 Mbps to stress coverage a bit more and was used in the NR study.  For 700 MHz UL, suggest both 30 kbps and 100 kbps, in order to consider more extreme coverage situations and to reflect VoNR.  For 4GHz, 10 Mbps is fine for DL, 1 Mbps is also fine for UL  Regarding the scenarios, we think the following should be defined:   * 700 MHz: Rural (7km ISD), LMLC (6km ISD), Extreme Long Range (173 km ISD) * 4 GHz: Rural (1732m, 3km ISD), Urban Macro (500m, 700m ISD)   We are open to discussing scenarios at 2 GHz, although we do not expect the bottleneck channels to be different than the ones we identify at 700 MHz and/or 4 GHz.  Please find our proposals for the scenarios in Appendix A4.1 |
| Sierra Wireless | Support the proposal. |
| NTT DOCOMO | Support the proposal. |
| CATT | Support |
| InterDigital | Support the proposed values |
| Qualcomm | Support the proposal |

(2) VoIP

**Proposal:**

* **Down select the following options for the codec of VoIP:**
* **Option 1: AMR 12.2 kbps**
* **Option 2: EVS 13.2 kbps**

Companies are invited to provide views on the above proposal.

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| **Companies** | **Comments** |
| ZTE | Our preference is TBS of 320 bits with 20 ms data arriving interval based on Option 1. |
| Nokia/NSB | According to GSMA VoLTE profile, The UE must support AMR wideband codec as described in TS 26.114. Therein, AMR-WB is defined as a mandatory codec, and even MTSI clients in constrained terminals shall support it. In our view, it seems reasonable to determine the reference value for the VoIP packet size to be used in this study according to the specification of the AMR-WB. We propose to consider the AMR-WB 12.65 (kbit/s) codec instead of AMR 12.2 kpbs as Option 1, i.e., a reasonable ‘legacy’ choice which offers a better sound quality than the traditional narrowband codec. Alternatively, we would propose to add it as Option 3 for now.  This results in TBS of 352 bits with 20 ms data arriving interval. |
| Nomor Research GmbH | Nomor supports the usage of option 1 with AMR, although we are also open to option 2. |
| Intel | Slightly prefer Option 1. |
| Ericsson | We do not have a strong view on the codec data rate itself.  Our understanding is that VoNR coverage is more likely to be limited by the SIP invite, which is on the order of 2kB as commented by Softbank in R1-2003464. So we would suggest further discussion of what data rates should be used considering the SIP invite. |
| Sierra Wireless | Both options acceptable-slight preference for option 1. |
| NTT DOCOMO | We prefer Option 1, and also we are open to Option2. |
| CATT | Option 1. As mentioned by ZTE, we should identify the TBS instead of only determining the data rate. As we mentioned in our contribution, 12.2kbps may lead to different understandings depends on how companies handle the headers. We are fine to use 320 bits as the starting point. |
| InterDigital | Option 1, to be aligned with TR 36.824. The corresponding TBS should be agreed for better alignment in evaluation. Similar to the proposal presented by ZTE, the arriving interval needs to be defined and our proposed value is 20ms. |
| SoftBank | Our preference is Option 2, but OK with Option 1 if majority of companies prefers Option 1.  As commented by Ericsson (and our contribution), we want to look at SIP invite issue when we identify the bottleneck for PUSCH. |
| Qualcomm | We prefer Option 2. EVS is the latest codec and has several enhancements over AMR. It is most likely to be widely used to supportVoNR services. Support for AMR through a legacy mode is supported within EVS. |

2.1.2 Evaluation methodology

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

* **Option 1: Based on link-level simulation**
* Step 1: Obtain the required SINR for the given target data rate.
* 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: China Telecom, Huawei, HiSilicon, CATT, vivo, LG, Intel, Sierra Wireless, MTK, Samsung, Nokia, Nokia Shanghai Bell, Panasonic, Lenovo, xiaomi, Sony, OPPO, Sharp, CMCC, Softbank, Charter, Apple, InterDigital, NTT DOCOMO, Qualcomm (25 companies)

* **Option 2: Based on link- level and system-level simulation**
* Step 1: Obtain the required SINR for the given target data rate 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)

* **Option 3: Based on system-level simulation for rural with long distance**

Support: Nomor

Based on the majority’s views, we have the following proposal:

**Proposal:**

* **Use the evaluation methodology based on link-level simulation for FR1.**
* Step 1: Obtain the required SINR for the given target data rate.
* 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.

Companies are invited to provide views on the above proposal.

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| **Companies** | **Comments** |
| ZTE | As for the methodology based on link budget, we are generally fine to adopt it as a benchmark for its simplicity. As for step 1, the target data rate is mainly for physical shared channels. So, it should be more accurate to say ‘Obtain the required SINR for ~~the given target data rate~~ the target physical channels under target scenarios and services’  But, SLS based method should be also considered due to the inaccuracy of link budget based method. For instance, ideal maximum beamforming gain is assumed in the link budget in ITU self-evaluation while it is not realistic since main lobe of the beam would be most possible not right against the UE. Especially for physical channels during initial access, the beam forming gain could be much lower due to the wide SSB beams.There are also other parameters may need more careful consideration, like interference density which cannot easily modeled in the link budget. In addition, shadow fading margin and penetration margin follow log-nominal distribution, and the margins are derived by the distribution at a target cell area reliability (e.g., 90% for physical shared channels). But the final SINR of a cell edge UE is a result of all influencing factors at the time. A UE with lower SNR doesn’t mean it will experience a bad shadow fading or a bad penetration loss.  So, we suggest Option 2 (Based on link- level and system-level simulation) is considered as an optional method. We may no need to align the assumptions for SLS. But, it seems also no need to preclude this method, and interesting companies can report their simulation assumptions and corresponding results. |
| Nokia/NSB | Support the proposal, if Step 1 is rephrased as “Obtain the required SINR for the target physical channel under target scenarios and services”. |
| Nomor Research GmbH | Nomor supports option 2.  In the link-level simulation, the users’ geometry distribution and network’s layout cannot be characterized, which would have impacts on issues such as beamforming gain and interference strength, as concerns are also raised on GTW1. System-level simulation is a tool that is useful for performance evaluation from a network perspective. In addition, for performance evaluation of specific solutions which are proposed by several companies to enhance coverage, system-level simulations are required. Link-level simulations are not solely enough to test the performance of those coverage enhancement methods. Therefore, we believe that eventually the need for system-level simulations will occur. System-level simulation considerations are already provided by Huawei, Ericsson, ZTE, IITH, CeWiT, IITM, Reliance Jio and Tejas Networks.  On the other hand, the approach that we have mostly used in our contribution [26] is not a full-scale system-level simulation for the baseline performance analysis, instead a similar one to the Option 2. We use system-level simulations to obtain SNR samples, and then convert those samples to throughput samples and look at the 5th percentile of CDF curve. That way, we can assess the performance of the system using the target throughput values defined in SID, i.e. 1Mbps DL and 100kbps UL throughput, for Rural scenario with long distance[1].  Nomor believes that system-level simulations should also be used to assess the coverage performance for FR1, along with link-level simulations, as the evaluation methodology to have better understanding of the system behaviour under different assumptions. |
| Intel | Given that coverage enhancement is mainly targeted for cell edge UE, which is typically noise limited scenario, we do not really see the need to conduct system level simulation for coverage enhancement study. This is also clearly described in the SID as “Identify baseline coverage performance for both DL and UL for the above scenarios and services based on link-level simulation”.  We acknowledge that in some scenarios, system level simulation may provide realistic results for coverage analysis. However, given the limited time for coverage enhancement SI, e.g., to align the system level simulation assumptions, etc, it would be more appropriate to mainly focus on the link level simulation for coverage analysis.  Based on the above, we suggest to focus on Option 1 for baseline coverage performance study. |
| Ericsson | We have similar views as ZTE.  We can also agree to use a link budget based approach, but believe it is essential that antenna gain and interference numbers are accurate, since the use of advanced antenna systems is so crucial to NR, and factors like downtilt and realistic antenna patterns in general must be taken into account. Defining the scenario properly will allow these numbers to be derived.  We similarly see no downside to defining system simulations, as these can only strengthen the outcome of the study. We will anyway identify the majority (if not all) of the parameters needed for the proposed link methodologies here, and as ZTE points out we may not need to align the SLS assumptions. Also, it is by no means clear how we determine the antenna gains and interference margins without some analysis of system level behaviour.  **Therefore we propose that both link and system level simulations can be reported.**  Regarding the proposal, in the second step we have determined the maximum supported loss as quantified by hardware link budget, MCL, available path loss, etc. Isn’t this sufficient to compare channels and identify bottlenecks? If absolute targets are agreed for the study, the performance can be compared against the target, but that is not an evaluation of the performance.  **So we would propose to remove Step 3 from evaluations.** |
| Sierra Wireless | As Intel points out, LLS is mentioned in the SID so for FR1, we support the FL proposal for option 1 with Nokia’s rewording slightly reworded:  “Obtain the required SINR for the ~~target~~ physical channels under target scenarios and services”.  I assume the agreed “target scenarios and services” is done before step 1 then. |
| NTT DOCOMO | We support the proposal. |
| CATT | Support the proposal. Agree with ZTE that the current wording can be more accurate, e.g. ‘Step 1: Obtain the required SINR for the given target data rate target physical channels’ to cover the potential channels does not require data rate.  Regarding to the comments on the SLS, we have the following comments:   * First of all, the link level simulation is used for identifying the baseline coverage performance has been agreed in the SID, we really don’t think we need to re-open the discussion here. * Secondly, as proposed by several companies, SLS may be more friendly to reflect certain aspects in the real world, e.g. beamforming gain. However, it should be also noted that the SLS and LLS are totally different evaluation mechanism, i.e. SLS considers much more factor from the system perspective and LLS only considers how a single link works. For example, SLS will consider the interference and traffic load whilst LLS won’t. I am not sure how the SLS+LLS can access the coverage in a more accurate way. On the other hand, the LLS-based evaluation methodology has been verified in ITU and should be sufficient for coverage evaluation. * Last but not least, we have strong concerns on the work load if SLS is also considered. |
| SoftBank | We are fine with the proposal, and open for additional (optional) system level simulation if time permits. |
| Qualcomm | We agree with the proposal but suggest some amendments:  Suggest that Step 1 be amended to reflect reliability requirements for control/non-data channels. Echoing Nokia/NSB, we propose the following amendment “Obtain the required SINR for the target physical channel under target scenarios and service/reliability requirements.”  Step 3 as currently worded is a little vague. Suggest amending this to “Identify coverage bottlenecks based on target performance metric” |

2.1.3 Simulation assumptions for obtaining the required SINR

Companies are encouraged to provide views on the common simulation assumptions for PUSCH and PUCCH in the following table.

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| **Parameters and descriptions** | **Companies** | **Comments** |
| **Number of receive antenna elements for BS:**   * Urban: 192 antenna elements,   (M,N,P,Mg,Ng) = (12,8,2,1,1)   * Rural: 64 antenna elements,   (M,N,P,Mg,Ng) = (8,4,2,1,1)  **Number of receive TxRUs for BS:**   * Option 1: 2 (The same value in IMT-2020) * Option 2: 4 * Option 3: 8 | ZTE | In our view, a lower number of antenna elements can be assumed for 700 MHz, e.g., 16 antenna elements. As for the TxRUs in urban scenario, we think 64 TxRUs, which is widely deployed in real network, should be also considered.  Overall, to alleviate the simulation burden, it may be better to discuss antenna configuration and carrier frequency together. So, our preference is:   * Urban at 4GHz:   + 192 antenna elements, (M,N,P,Mg,Ng) = (12,8,2,1,1);   + 4 or 8 or 64 TxRUs * Rural:   + For 700 MHz: 16 antenna elements with (M,N,P,Mg,Ng) = (8,1,2,1,1) for rural and rural with long distance; 2 TxRUs.   + For other carrier frequencies in FR1: 64 antenna elements with (M,N,P,Mg,Ng) = (8,4,2,1,1) for rural and rural with long distance. 2 or 4 TxRUs. |
| Nokia/NSB | Antenna elements: Support the proposal for number of receive antenna elements for BS. Open to consider other values for rural scenarios.  TxRUs: Option 1. Open to discuss other options as well, but IMT-2020 value is indeed preferred. |
| Nomor Research GmbH | Antenna Elements:  Nomor supports the number of antenna elements proposed on BS for rural and rural with long distance scenarios.  The proposal corresponds to our simulation assumption on the rural with long distance scenario, and also to the one we have used in IMT-2020 evaluation studies for rural scenario.  Nomor does not have objections for the proposal of urban scenario.  TxRUs:  Nomor supports option 3.  We have already used 4TxRUs per polarization in our IMT-2020 evaluation, where we have 4 columns of antenna elements per polarization in our system-level simulations. This is also the assumption we have used in [26]. Therefore, Nomor supports the idea that 8TxRUs (Mp,Np) = (1,4) should be used for the rural and rural with long distance scenarios. This is also mentioned as the baseline assumption in IMT-2020 evaluation process by some other companies in GTW1.  In the urban scenario with the BS antenna configuration proposed above, there should clearly be sub-array partitioning in vertical domain, i.e. Mp>1, due to the flatness of a beam generated by a column of 12 antenna elements and the wide variety of elevation angles under which the BS can see the UEs. Hence, here too, in our opinion there should be at least 8TxRUs, e.g. (Mp,Np)=(2,2) or even 16 TxRUs (Mp,Np)=(2,4). |
| Intel | For number of receiver antenna elements for BS, we prefer a smaller number of antenna elements. In particular,   * + 1. For 700MHz carrier frequency, 16 antenna elements     2. For 4GHz carrier frequency, 64 antenna elements. We are open for > 64 antenna elements, e.g., 128.   For number of receive TxRU for BS, we prefer option 1. |
| Ericsson | For 700 MHz: 16 antenna elements with (M,N,P,Mg,Ng) = (8,1,2,1,1) or (8,2,2,1,1) 2 or 4 TxRUs; (4x1 virtualization).  For 4 GHz: 128 antenna elements with (M,N,P,Mg,Ng) = (8,8,2,1,1) 32 TxRUs, (4x1 virtualization)  See details in Appendix A4.1 |
| Sierra Wireless | For 700MHz - 16 antenna elements For 4GHz - open for >= 128 antenna elements  TxRUs: not a strong view. |
| NTT DOCOMO | **Number of antenna element**  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 prefer Option 2 (4), since UE shall have more than 4 Rx ports, so that 4 TxRUs may be sufficient for the 4x4 MIMO transmission. |
| CATT | The array gain has been addressed in the link budget template. In the LLS, what we really care is the number of antenna port. I am not sure why do we need to consider the configuration of antenna elements in LLS assumptions? We think it should it should have the same assumption as number of receive TxRUs for BS, i.e. the physical antenna configuration is aligned with the antenna port, and the antenna configuration for gNB should be 2Tx/2Rx.  If the intention is that the configuration provided here is only used in the link budget template, we support it. Accordingly, we don’t need to capture the antenna array configuration here. |
| InterDigital | We would like to clarify how the parameters defined here translate to the number of antennas at BS in the link level simulation. For example, does p=2 correspond to 2 antennas at BS? We proposed “2” for the number of RX antennas at BS in our contribution. |
| SoftBank | **Number of antenna element**  Same view as DOCOMO. |
| Qualcomm | We propose an alternate option on the number of antenna elements: 64 antenna elements for urban and 4 antenna elements for rural.  The number of antenna elements should be a function of the carrier frequency. For the 700 MHz band, we think a gNB may have no more than 4 antennas. For a gNB operating close to 4 GHz, the gNB may have anywhere from 64 to 512 antenna elements.  We propose Option 4 for number of TXRUs: 64 TXRUs for urban and 4 TXRUs for rural.  The number of receive TXRUs should a function of the carrier frequency. For the 700 MHz bands, a gNB can have up to 4 TXRUs, while for bands close to 4 GHz, the gNB typically has 32-64 TXRUs. |
| **Delay spread**   * + urban: TBD   + rural: TBD   + rural with long distance: TBD | ZTE | Our preference is:   * + urban: 300ns   + rural: 300ns   + rural with long distance: 30ns |
| Nokia/NSB | Rural FDD/TDD:   * NLOS: TDL-C 37ns * LOS: TDL-E 32 ns   Urban TDD:   * NLOS: TDL-C 363ns   LOS: TDL-E 93 ns |
| Intel | We assume delay spread of 100ns. But we are open to consider 300ns in the simulations. |
| Ericsson | If only one delay spread is defined for link level simulations, we prefer 100ns. If we have two delay spreads defined for LLS, then we would like 30ns & 300ns. |
| NTT DOCOMO | Our preference is as follows.  Urban : 240 ns  Rural : 363 ns |
| CATT | The same calculation mechanism used in ITU could be employed here.  Rural FDD/TDD   * TDL-C, 37ns for NLOS O2O * TDL-C, 34ns for NLOS O2I   Urban TDD:   * TDL-C, 240ns for NLOS O2I   Rural with long distance:  TDL-D, 300ns |
| InterDigital | We propose to use TDL-C with DS 616ns and 153ns for urban and rural, respectively. |
| Qualcomm | Proposed values:  Rural: 37 ns  Urban: 363 ns  For delay spreads we use Table B.2.1-1 in TR 37.910. Non-LoS channel models are used as they pose a more challenging environment compared to LoS channels. |
| **Latency requirements for voice:**   * Option 1: 50ms * Option 2: 100ms * Option 3: Other values | ZTE | Option 3 with 20 ms. |
| Nokia/NSB | Option 1 should be considered as baseline for evaluation. Relaxed latency requirements, e.g., 100 ms, may be considered if evaluation results show coverage limitation with 50ms latency. |
| Nomor Research GmbH | Nomor supports option 2.  Our suggestion is to stick to the regular packet delay budget for 5QI = 1, which is 100ms for conversational voice. Therefore, latency requirement for voice supported to be defined as 100ms one way, including at the rural scenario with long distance. |
| Intel | Option 1. |
| Ericsson | T.B.D. |
| Sierra Wireless | Option 2 is preferred as it would support higher coverage. But can accept Option 1. |
| CATT | We are flexible on the value. The key issue is to there should be a value acceptable to all, and more importantly, how should we simulate the latency in LLS? |
| InterDigital | Option 1, following TR 36.824 |
| SoftBank | We support the comment by Nokia (i.e. Option 1 for baseline) |
| Qualcomm | We propose Option 3: 20 ms.  Although a total latency (mouth-to-ear delay) of up to 150 ms is considered tolerable for voice services, this delay budget is split across upper and lower layers and is not directly applicable to this evaluation. We prefer to assume that a new voice packet is generated every 20 ms and that this packet is to be delivered to the receiver within a 20 ms window. |
| **Number of PRBs for control channel:**   * Option 1: 1 PRB. * Option 2: Other values. | ZTE | Option 1 is preferred. |
| Nokia/NSB | Option 2. In our view the occupied channel bandwidth in case for format 3, especially for 22 bits UCI payload, could be increased to 2 PRBs. |
| Nomor Research GmbH | Nomor supports option 1. |
| Intel | We assume this is for PUCCH format 3. The PRB size depends on the UCI payload size and number of symbols for PUCCH. If the UCI payload size is ~20bits and 14 symbols are assumed, 1 PRB is sufficient.  Option 1 is preferred, but we need to clarify the number of symbols for PUCCH in the simulation. |
| Ericsson | 1 PRB is fine for PUCCH; see other channels in Appendix A4.1 |
| NTT DOCOMO | We support Option 2. Each companies can decide the values for their simulation, based on their assumption, e.g. UCI payload size. |
| CATT | Option 1 |
| Qualcomm | We support option 1. |
| **PRBs/TBS/MCS for data channel:**  **Number of PRBs:**   * Option 1: 30PRBs for urban eMBB, 4 PRBs for urban VoIP, 4 PRBs for rural and rural with long distance. * Option 2: Other values.   **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. | ZTE | Regarding the number of RBs, Option 2 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 1.  On TBS and MCS: Option 1 is preferred. |
| Nokia/NSB | Number of PRBs: Option2.  PDSCH: full bandwidth allocation is preferred for eMBB and 4 PRBs for VoIP.  PUSCH: setting a fixed occupied bandwidth for eMBB service, without accounting for MCS selection, is highly sub-optimal for PUSCH coverage enhancement. This approach can lead to non-negligible underestimation of the MPL of PUSCH, as shown in R1-2004178 (more than 2 dBs), and thus it should be discouraged. In this context, MCS Table 5.1.3.1-3 in TS38.214 (‘qam64LowSE’) provides a set of MCS indices which enables the allocation of larger occupied PUSCH bandwidth and achieve coverage enhancement. Suitable MCS/number of PRBs couples can be found for each scenario. In our view, this approach is more appropriate to the scope of this study.  If we cannot afford discussing values for each scenario, we would suggest identifying the number of PRBs as a function of MCS index and scenario. A sensible approach seems to be considering ‘qam64LowSE’ table setting a maximum MCS index for the study, depending the frame structure, for instance:   * Rural long distance: MCS4 -> 5 PRBs * Rural TDD (DDDSU): MCS3 -> 13 PRBs * Rural TDD (4D1S5U): MCS0 -> 13 PRBs * Urban (DDDSU): MCS7 -> 55 PRBs * Urban (4D1S5U): MCS3 -> 55 PRBs   If RAN1 can agree on the spirit of this approach, we are open to consider different values.  4 PRBs for VoIP seem reasonable and we agree to that.  TBS and MCS: Option 1 is preferred. However, as aforementioned, the optimal MCS/number of PRBs couple that provides the “best coverage” should be considered instead of fixing the number of PRBs. |
| Nomor Research GmbH | Nomor supports option 1 for both Number of PRBs and TBS and MCS. |
| Intel | We would like to clarify that the number of symbols is also important for coverage analysis, e.g., for selection of the number of PRBs and MCS. In our study, we assume 14 symbols for both PUSCH and PUCCH.  For the number of PRBs, we prefer Option 2. However, for VoIP and 100kbps in rural scenario, 4 PRBs can be assumed.  For TBS and MCS, we prefer option 1, but we would like to consider aligned simulation assumptions including TBS/MCS among companies so as to provide meaningful study for baseline performance study. In our preliminary study, it was observed that different combinations of TBS/MCS and the number of PRBs can result in substantial performance difference. In our view, a general consideration is that QPSK and code rate <1/3 are employed for PUSCH simulation. |
| Ericsson | **For number of PRBs:** PRBs and MCS need to be selected according to TBS, BLER target and/or assumed number of retransmissions, etc, so prefer option 2. If results show that option 1 works, that can be OK as well.  **For TBS:** Option 1 should be baseline, but if option 2 is shown to be equivalent, that can be used as well. |
| NTT DOCOMO | We prefer that each companies can decide the values for their simulation, based on their assumption, e.g. considering “small number of RBs with high coding rate” vs “large number of RBs with low coding rate”.  If we define the number of PRBs, we prefer as follows, and number of PRBs for VoIP/eMBB may be different due to different target data rate.  VoIP : 4  eMBB : 15 (Urban), 2 (rural) |
| CATT | Number of PRBs: Option 1  TBS and MCS: I am not sure I fully understand option 2. From my understanding, either is OK as TBS and MCS always depend on the number of PRBs/data rate/frame structure/overhead. 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. |
| InterDigital | 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 for better alignment of the results among the companies. |
| Qualcomm | We make the following proposals for PRBs:  For PUSCH: 30PRBs for urban eMBB, 1,2 or 4 PRBs for urban VoIP, 1,2, or 4 PRBs for rural and rural with long distance.  For PDSCH: Assume full band allocation. 100 MHz in the case of 4 GHz, and 20 MHz in the case of 700 MHz.  For TBS and MCS selection:  We support Option 1. |
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| **Number of repetitions for PUSCH and PUCCH** | ZTE | For VoIP, PUSCH repetitions should be enabled. Repetition number 2 or 4 or 8 can be considered.  Enabling PUCCH repetitions should be careful. It will impact not only the UCI payload, but also the transmission of PUSCH (as the spec copied below).  ‘*If a UE would transmit a PUCCH over a first number  of slots and the UE would transmit a PUSCH over a second number of slots, and the PUCCH transmission would overlap with the PUSCH transmission in one or more slots, and the conditions in Clause 9.2.5 for multiplexing the UCI in the PUSCH are satisfied in the overlapping slots, the UE transmits the PUCCH and does not transmit the PUSCH in the overlapping slots*.’ |
| Nokia/NSB | PUSCH aggregation factor should be considered. The number of repetitions should be set depending on the frame structure and number of retransmissions (we must ensure not to exceed the latency requirement). We are not in favour of PUCCH repetitions, for the same reason as ZTE. |
| Nomor Research GmbH | Nomor does not support repetition for eMBB and supports 8 PUSCH repetitions (i.e. aggregation factor 8) for VoIP on rural scenarios, including rural with long distance.  We have shown in **エラー! 参照元が見つかりません。** that repetition does not bring significant benefit in terms of coverage for eMBB, rather it enhances the coverage performance of VoIP significantly in case of rural with long distance scenario.  PUCCH should also be satisfying the target BLER requirement at the minimum required SINR of PUSCH. Number of repetitions should be aligned accordingly. |
| Intel | For PUSCH, repetitions can be considered.  For PUCCH baseline performance, repetition may not be assumed, especially considering the TDD scenario. |
| Ericsson | 2, 4, or 8 can be considered in general according to Rel-15/16  TBD: if VoIP repetition is used. |
| Sierra Wireless | For PUSCH, repetitions can be considered for baseline performance if data rate is maintained. |
| NTT DOCOMO | We support to apply PUSCH repetition and number is 4 or 8 (we are open for the discussion.).  For PUCCH, we also support PUCCH repetition and number is 4. |
| CATT | The repetition should exploit the full power of coverage.  For VoIP, repetition number 8 can be used.  For PUCCH, repetition number 8 can be considered in order to achieve the best coverage performance. Considering the impact on the PUSCH transmission mentioned by ZTE, we think it is not the issue in coverage topic and can be handled by gNB. In the other words, gNB have the full power to determine whether repetition is on or off depending on what kind of result it want to get.  For eMBB, it is a tricky situation. It’s true that repetition will increase the MCS level which is harmful for performance. However, time domain diversity gain and combination gain can also be harvested. It will be a trade-off between the performance loss and the performance gain(maybe need several shot to find the best combination). The whole idea is that what kind of performance we can get with the current functionality. We are open to discuss the potential number but that we should leave a door to eMBB. |
| InterDIgital | We propose 4 per bundle for PUSCH for 15kHz SCS. Appropriate number for repetition for each SCS should be agreed. |
| Qualcomm | PUSCH with no repetitions should be considered for eMBB traffic, while PUSCH with repetitions should be considered for voice traffic.  For PUCCH, we need to evaluate with and without repetition.  PUCCH repetition cannot be used an option to improve coverage of HARQ-ACK transmission.  Typically, downlink transmissions from a gNB are scheduled such that the downlink data buffers are emptied as fast as possible. This results in a continuous burst of downlink transmissions to a UE until the buffers are fully emptied. Once emptied the gNB then lets the UE transition to idle mode (important for power saving). Since PUCCH transmissions carrying HARQ ACK/NACK payload is in response to a continuous burst of downlink data transmissions, repeating a PUCCH transmission is not be possible.  To illustrate this, consider a DDDSU TDD slot pattern where PUCCH Format 3 is used to carry 4 HARQ ACK/NACK bits every uplink slot. Consider enough data in the downlink data buffers that a UE receives a continuous burst of downlink data over 20 downlink slots. In such a scenario, as HARQ ACK/NACK bits start to accumulate on the UE side, there is no scope to accommodate PUCCH repetition. 4 HARQ ACK/NACK bits have to be transmitted every uplink slot until the end of the burst. It is therefore important to evaluate PUCCH without repetitions under such scenarios.  PUCCH carrying CSI payload may adher to a slightly more relaxed timeline and it may be possible to allow PUCCH repetitions in such a case. |
| **Frequency hopping for PUSCH and PUCCH** | ZTE | FH is disabled for PUSCH with one DMRS with UE speed of 3km/h, and enabled for PUSCH with two DMRS(one DMRS per hop) with UE speed of 120km/h. |
| Nokia/NSB | Rel-16 intra-slot frequency hopping should be considered both for low and high speed UEs (one DMRS per hop). |
| Nomor Research GmbH | Nomor supports inter-slot frequency hopping for PUSCH.  Our results in **エラー! 参照元が見つかりません。** have shown that inter-slot frequency hopping significantly enhances the coverage performance on rural with long distance scenario. Thus, Nomor fully supports this proposal and even would like to enhance the standardized inter-slot frequency hopping procedure |
| Intel | Intra-slot frequency is assumed. In the simulation, frequency hopping should be enabled. |
| Ericsson | See Table B comments and details in Appendix A4.1 |
| Sierra Wireless | The baseline can assume FH is enabled (either inter or intra). |
| NTT DOCOMO | Frequency hopping may be assumed. |
| CATT | ON |
| Qualcomm | Inter-slot frequency hopping can be enabled for PUSCH. Intra-slot frequency hopping splits DMRS resources and makes channel estimation challenging. 1 DMRS per hop may not be sufficient.  Intra-slot frequency hopping can be enabled for PUCCH. Inter-slot frequency hopping for PUCCH is tied to PUCCH repetitions and we are proposing that we evaluate PUCCH without repetitions especially for HARQ ACK/NACK payloads. |
| **HARQ configuration** | ZTE | Is this trying to say the maximum number of re-transmissions? If so, a maximum of 4 re-transmissions (including the initial transmission) is preferred for PUSCH carrying VoIP. For PUSCH with eMBB, no re-transmission is assumed for10%iBLER. |
| Nokia/NSB | No retransmission for eMBB (reliability target for SNR is 10% BLER).  For VoIP, given the BLER requirement, we would like to highlight the need to agree on the number of retransmissions, which in turn should depend on the TDD frame structure. In case of DDDSU, for instance, 4 re-transmissions (including initial transmission) can be considered and are our preferred choice. |
| Nomor Research GmbH | For VoIP, in case 8 PUSCH repetitions are considered, as mentioned above, Nomor supports 2 HARQ transmissions. |
| Intel | It may depend on the repetition for PUSCH. |
| 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 A4.1 |
| Sierra Wireless | Since HARQ dramatically improves coverage, the baseline can assume HARQ is used. For eMBB, a maximum number should be agreed at [4] attempts. For VoIP, HARQ can be used as long as the latency requirement is not exceeded. |
| NTT DOCOMO | We prefer 4 for the maximum number of HARQ transmission. |
| CATT | No sure whether we need to consider re-transmission. The HARQ gain has been considered in link budget template. |
| InterDigital | HARQ sequence can be 0,2,3,1. We should agree on the number of HARQ processes, which depend on the number of repetitions. For PUSCH, we propose 12 and 3 for the number of HARQ processes, when repetition is on (number of repetitions is 4 for 15kHz SCS), and off, respectively |
| Qualcomm | Since eMBB targets 10% iBLER, no need for any HARQ considerations.  For Voice, if we switch to 10% iBLER, then this becomes similar to eMBB. Else, number of allowed retransmissions become dependent on TDD Frame structure, latency requirements, and PUSCH repetitions.  For example, for DDSU slot pattern, with a 20 ms window for packet transmission, 10 uplink slots exist within a 20 ms window. Setting aside 2 slots for long PUCCH leaves us with 8 uplink slots which can either be used for PUSCH with 2 repetitions and maximum 4 retransmissions or alternately, 4 repetitions with a maximum of 2 retransmissions. |
| **Other parameters** | ZTE | The waveform should be clarified. In our view, DFT-s-OFDM can be assumed for coverage enhancement. |
| Intel | We share similar view as ZTE. DFT-s-OFDM waveform should be assumed as baseline for PUSCH coverage analysis.  Further, the number of symbols for PUSCH/PUCCH transmission need to be clarified in the simulations. |
| Ericsson | For waveform: DL: OFDM, UL: DFT-S-OFDM  Our detailed proposals for channel configurations are in Appendix A4.1 |
| CATT | The DMRS power boosting should also be considered for PUSCH transmission. |
| 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. |

* PUSCH

Companies’ views on simulation assumptions for PUSCH for link-level simulation for FR1 are summarized in Appendix 1. Based on the majority’s inputs, we have the following proposal:

**Proposal:**

* **Adopt Table A for PUSCH for FR1.**

Table A Simulation assumptions for PUSCH for FR1

|  |  |
| --- | --- |
| Parameters | Values |
|  Scenario and frequency | * Urban: 4GHz(TDD), 2.6GHz(TDD) * Rural: 4GHz(TDD) , 2GHz(FDD), 700MHz(FDD) * Rural with long distance: 700MHz(FDD) |
|  Frame structure for TDD | DDDSU, DDDSUDDSUU, DDDDDDDSUU |
| BLER | 10% for eMBB, 2% rBLER for voice |
|  Pathloss model (select from LoS or NLoS) | NLos for urban and rural, LoS for rural with long distance |
| Channel model for link-level simulation | TDL-C for urban and rural, TDL-D for rural with long distance |
| UE velocity | 120 km/h for outdoor, 3 km/h for indoor |
| Number of UE antennas | 2 for urban, 1 for rural and rural with long distance |
| Number of TRXU for UE | 2 for urban, 1 for rural and rural with long distance |
| DMRS configuration | DMRS:  - For 3km/h: Type I, one DMRS symbol, no multiplexing with data.  - For 120km/h: Type I, 2 DMRS symbol (one front- loaded and one additional), no multiplexing data |

Companies are invited to provide views on the above proposal.

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| ZTE | We are generally fine with above assumptions. One clarification on DMRS configuration: is it per PUSCH or per frequency hop? Our understanding is per PUSCH. Then, FH is not enabled for PUSCH with one DMRS for 3km/h. |
| Nokia/NSB | Scenario and frequency: In principle we agree with the proposed values, however we would think that considering all of them as “mandatory” may lead to an excessive redundancy for the discussion and simulation. We would prefer to prioritize them as follows: Urban: 4 GHz (TDD) to be considered for the study and 2.6 GHz as optional; Rural: 4 GHz (TDD) and 700 MHz (FDD) to be considered for the study and 2 GHz (FDD) as optional.  Frame structure: In our view, setting a fixed frame structure for TDD deployments does not leverage the flexibility offered by NR frame structure in such scenarios. In particular, this choice is sub-optimal for coverage enhancement, as shown in R1-2004178. Therein we showed that an MPL enhancement of 2.7 to 3.8 dB, i.e., a coverage increase of around 20%, can be observed if the frame structure is set to account for the specific PUSCH throughput target while exceeding the throughput target for PDSCH. We prefer to replace either DDDSUDDSUU or DDDDDDDSUU with 4D1S5U (10D:2G:2U) in the list of considered frame structure for evaluation.  Channel model: Similar to IMT-2020, our preference is to differentiate between NLOS and LOS propagation, and not between Urban and Rural. Hence, we prefer TDL-C for NLOS (rural, if applicable, and urban) and TDL-E for LOS (urban, if applicable, and rural).  UE speed: In our view, it is reasonable to differentiate between Urban and Rural when considering high speed UEs. Setting 30 Km/h for Urban scenarios and 120 Km/h for Rural seems more reasonable. Low speed UEs should move at 3 Km/s, both indoor and outdoor.  Number of UE antennas: Our preference is to consider the same UE configuration for both Urban and Rural. This seems more reasonable. We would prefer 2 antennas for UE in both cases.  Number of TXRUs for UE: Our preference is to consider the same UE configuration for both Urban and Rural. This seems more reasonable. We would prefer 1 TXRU for UE in both cases, which seems more suitable for coverage studies. |
| Nomor Research GmbH | Nomor supports the assumptions on Table A, except items indicated below:  - LoS for rural with long distance: We believe that as for rural scenario, rural with long distance should also cover NLoS, since NLoS will be the bottleneck of the system, rather than LOS. Since we are looking at the coverage performance in this study, not considering NLoS can cause problems for the UEs that are actually NLoS in real world scenarios. In addition, we have shown in [26] that the system performance can be enhanced by various techniques, and the performance of the system including UEs that are NLoS, can meet performance criteria determined in [1]. Therefore, Nomor proposes to evaluate both LoS and NLoS separately for the rural long distance scenario.  - Nomor believes that 2 UE antennas and 2 TxRUs should be used, instead of 1, as up to 2 antennas were allowed in IMT-2020 evaluations for rural with long distance. |
| Intel | In general, we are fine with the above assumptions, but with some comments:   * We suggest to select one carrier frequency for each deployment scenario so as to reduce simulation effort. For instance,   + Urban: 4GHz (TDD),   + Rural: 700MHz (FDD).   + Rural with long distance: 700MHz (FDD) * Subcarrier spacing needs to be clarified. We suggest 700MHz with 15kHz SCS and 4GHz with 30kHz SCS. * For frame structure for TDD, we suggest to select first one for simulations. As mentioned by other companies, DDDSU and DDDDDDDSUU do not seem much difference for simulation. Further, detailed configuration for S slot needs to be clarified. * For number of antennas, we suggest to use same number of antennas for urban and rural scenario in the simulation. We prefer 1 for urban scenario. * For channel model, we slightly prefer TDL-A in the simulation. If majority of companies support TDL-C or D, we are fine to consider for the simulation. * DMRS configuration and positions depend on the number of symbols. Suggest to align the number of symbols allocated for PUSCH. |
| Ericsson | BLER, HARQ, and DMRS assumptions are already covered in the PUSCH and PUCCH table above, and so not needed in Table A.  TDL-A is used for extreme long range coverage scenario in 38.802, and so should be used for 700 MHz in that scenario.  Medium correlation should be used for TDL models.  We think 1 UE Tx antenna should be used, and 2 Tx antennas can also be studied. But this should be consistent across scenarios. 2 UE Rx antennas should be used for 700 MHz, and 4 UE Rx antennas should be used for 4 GHz.  We think at least 3 DMRS symbols should be used for PUSCH as commented above. Agree that UL data should not be multiplexed with UL DMRS.  Details are in Appendix A4.1 |
| Sierra Wireless | Mostly fine. Some comments:   * This looks like a lot of scenario to evaluate. It would be good narrow this down. * Urban: 4GHz(TDD), ~~2.6GHz(TDD)~~ * Rural: ~~4GHz(TDD)~~ , 2GHz(FDD~~), 700MHz(FDD)~~ * Rural with long distance: 700MHz(FDD) * 1TX UE antenna for all scenarios * Subcarrier spacing- 4 and 2 GHz with 30kHz SCS, 700MHz at 15kHz   Reduce frame structures for TDD – pick one, two max |
| NTT DOCOMO | We have some comments for the assumption.   * BLER : 10% for eMBB is iBLER or rBLER ? We prefer to use rBLER for eMBB as well to consider HARQ. * UE velocity : We may consider 3km/h for outdoor as well considering pedestrian. 120 km/h seems too fast to consider the coverage performance. * Number of UE antennas : We prefer to use the same number (2) for both Urban and rural scenarios.   DMRS configuration : It’s up to the number of OFDM symbols for PUSCH. We prefer to use dense configuration, e.g. 1 DMRS symbol (one front- loaded and three additional) for 14 symbols. |
| CATT | Frame structure for TDD: As mentioned by Nokia, we are open to discuss whether to introduce a UL-dominated TDD UL-DL frame structure to exploit the full power of UL coverage.  Furthermore, we don’t think there is significant difference between DDDSU and DDDDDDDSUU. The frame structure is used to determine the TBS based on the target data rate. The only different is that the former has one special subframes and the later has two. Considering the UL-DL structure of a special subframe is typically DL dominated, it really doesn’t make much difference on the final TBS. But it will significantly increase the work load on simulation. We propose only adopt one of them as the simulation assumption.  In addition, we should spell out what the UL-DL configuration on the special subframe to guarantee everyone on the same page.  Codec for voice: It’s better to clarify how we handle the header bits. In our opinion, the 12.2 kpbs is the data rate of pure voice data. The final TBS transmitted in PHY will include some header bits.  AP assumptions for UE: We think the same configuration should be applied to both urban and rural scenario. A UE can move from urban area to rural scenario and vice versa, it doesn’t make sense that the same UE can use 2TX\*2RX in urban area while can only use 1 TX\*1RX in rural area.  General comments1: The TBS or the SE will be calculated based on the target data rate and the frame structure. It should be clarified whether we take the BLER into account when calculate the TBS/SE. It will have significant impact on the final LLS assumption parameters.   * Understanding 1: Target data rate is defined without considering BLER. It means the data rate would be the ideal one assuming there are not error blocks. For example, the TBS used in LLS will be determined by target data rate 10Mbps. * Understanding 2: Target data rate is defined with considering BLER. It means the data rate is calculated only based on the blocks which are correctly received. For example, the TBS used in LLS will be determined by (10/0.9) Mbps if the target data rate is 10 Mbps.   General comments 2: The DMRS power boosting should also be considered. If the DMRS is configured as without data, the power of DMRS can be boosted to enhance the performance. |
| InterDigital | * For frame structure, referring to TR 36.284, we propose DDSUU since 2 out of 5 slots are reserved for UL in TR 36.284. We are also open to considering a frame structure that maximizes performance in both DL and UL. * We agree with the BLER target and pathloss model. * For UE velocity, we should incorporate 3km/h for outdoor. In our view, low-mobility UEs exist in realistic scenarios. * For number of UE antennas, “1” should be included for urban scenario, resulting 1 TXRU. * For DMRS for PUSCH, we propose to use two DMRS symbols for 3km/hr according to our simulation results in R1-2004304. From our results, it is clear that increasing # of DMRS symbols improves channel estimation, and increasing beyond 2 will cause throughput loss. As the best tradeoff between channel estimation performance and throughput, we believe 2 DMRS symbols should be used, even for low-mobility scenario. We should also clarify whether PUSCH mapping type A or B should be used. We prefer to use PUSCH mapping type B. |
| Qualcomm | We would like to make the following comments:   * We should downselect the number of urban and rural scenarios to evaluate. We feel that it suffices to evaluate urban scenarios at 4 GHz and rural/extreme rural scenarios at 700MHz. * For frame structure, we prefer to also include DDSU. * For voice, it may suffice to evaluate 10% iBLER as a subsequent re-transmission may further reduce BLER to the desired 2% rBLER. * Channel model can be move to the table that discusses parameters common to all PHY channels. * We should consider the CDL channel model for link-level simulations. The choice between TDL and CDL depends on how beamforming gains are to be captured in the link budget. There are serious concerns that using a TDL channel model may not sufficiently capture the variability in the beamforming gains experienced by a cell-edge UE. * For VoIP and rural scenarios, we would like to consider 1, 2, and 4 RB allocations. * For DMRS, we believe at least 2 DMRS symbols need to be included for a cell-edge UE. This should not be restricted to high doppler scenarios. * Allow single tx UE for urban scenarios as well. |

* PUCCH

Regarding the simulation assumptions for PUCCH for FR1, most parameters can be reused from PUSCH for FR1. Some channel-specific parameters for PUCCH are summarized based on companies’ inputs in Appendix 2.

Based on the majority companies’ views, we have the following proposal:

**Proposal:**

* **Adopt Table B for PUCCH for FR1.**

Table B Simulation assumptions for PUCCH for FR1

|  |  |
| --- | --- |
| Parameters | Values |
| Format type | Format 1, 2bits UCI  Format 3, 11/22 bits UCI |
| Number of UE antennas | 1 |
| Number of TRXU for UE | 1 |

Note: Other general parameters for PUCCH can be reused from PUSCH.

Companies are invited to provide views on the above proposal.

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| ZTE | We support above assumptions. In addition, it’s better to clarify the BLER target. 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% |
| Nokia/NSB | We support the proposal in principle. However, since it is noted in the proposal that other parameters for PUCCH can be reused from PUSCH, we prefer to discuss on the assumptions for PUSCH first. We note that this is also aligned with the general understanding that PUSCH is the most likely candidate to be the NR coverage bottleneck. |
| Nomor Research GmbH | Nomor supports the proposal. |
| Intel | We are fine with the above assumptions. We also share similar view as ZTE that performance metric should be clarified. The performance metric from ZTE looks good to us.  Further, for PUCCH format 3, we suggest to select one UCI payload size to reduce simulation effort. We prefer 22 bits UCI payload size for the simulation. |
| Ericsson | For ACK/NACK:   * Format 1 with 1bit, 14 symbols long with 7 DMRS and frequency hopping * Pr(DTX to ACK) <=1%, Pr(NACK to ACK) <=0.1%, * Pr(ACK error) <=1% or 10%   For CSI (on PUSCH or PUCCH):   * 5+2 bits for wideband CSI feedback for 2Tx * 1 PRB, no HARQ ACK/NACKs * PUCCH format 3 with 4 DMRS and frequency hopping * PUSCH without multiplexing with data on PUSCH and no frequency hopping * 1% and 10% error rate |
| Sierra Wireless | Supports the proposal. |
| NTT DOCOMO | We are fine for the proposal, and also agree with ZTE to define the performance metric. Our preference is 1 % BLER for all formats.  We prefer to select PUCCH format for FR1, and our preference is to use long format for FR1. |
| CATT | For PUCCH format 1, 1 bit UCI should be used. |
| Qualcomm | We support this proposal. |

2.1.4 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: China Telecom, Huawei, HiSilicon, CATT, vivo, LG, Intel, Sierra Wireless, MTK, Samsung, Nokia, Nokia Shanghai Bell, Panasonic, Lenovo, xiaomi, Sony, OPPO, Sharp (18 companies)

* **Option 1-2: Adopt link budget template in TR 36.824**
* The calculated MCL is considered as the baseline performance.

Support: Softbank, Charter, Apple, InterDigital, NTT DOCOMO, Qualcomm, Verizon, InterDigital, Sharp (9 companies)

Companies are invited to provide views on the above options.

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| ZTE | Choosing from above two options, we slightly prefer Option 1-1. |
| Nokia/NSB | Same view as ZTE. |
| Nomor Research GmbH | Nomor supports the option 1-1. We are not against option 1-2, either. |
| Intel | We slightly prefer Option 1-1, but we are open to consider Option 1-2.  In our view, 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. |
| 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 C below. |
| Sierra Wireless | Slight preference for Option 1-1 |
| NTT DOCOMO | We prefer Option 1-2, since it may be difficult to have a common parameters for the assumption (e.g. some of the parameter may be different over deployment scenario, etc.). |
| 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. |
| InterDigital | We support Option 1-2 |
| SoftBank | We support Option 1-2  As discussed during GTW1 on Monday, voice coverage is offered by refarming band with low frequency, and aggressive antenna/beamforming gain cannot be expected. In our understanding, approach by Option 1-1 with ISD/MPL target expects the coverage extension by antenna/beamforming gain. Therefore, Option 1-1 wouldn’t be appropriate for this scenario.  In addition, we support the argument by DOCOMO, which is definitely the benefit to use MCL based approach |
| Qualcomm | We prefer using Option 1-2. |

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 A 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 C for the baseline performance calculation for FR1.**

Table C Link budget template in IMT-2020 self-evaluation for FR1

|  |  |
| --- | --- |
| **Parameter** | **Values** |
| Scenario | TBD |
| Frame structure | TBD |
| Carrier frequency (Hz) | TBD |
| BS antenna heights (m) | 25m for urban, 35m for rural |
| 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) | 1 for UL, 3 for DL |
| (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) | 0 for DL, 8 for UL |
| (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) | 1 for DL, 3 for UL |
| (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** |
| ZTE | We are fine with above template. |
| Nokia/NSB | From our perspective, the difference between control and data channels in terms of reliability targets and retransmission framework (data channels can have HARQ whereas control channels do not) is already accounted for when setting BLER requirements for SNR/SINR, i.e., 10% BLER for data and 1% BLER for control). Setting different cell area reliability between the two channels may not be necessary in this context. The latter parameter is related to shadow fading assumptions and represent the percentage of the cell for which coverage is guaranteed. We would like to discuss the reasons why such percentage should be different between the two channels. |
| Nomor Research GmbH | Nomor supports the proposal with slight concerns on particular issues mentioned below.  Note 1 indicates that the channel model for path loss calculation is defined in Report ITU-R M.2412. Firstly, there are two channel models, A and B in this report. Nomor would like to propose channel model B to be used in the evaluations. In addition, both of the channel models are not valid for distances greater than 21km. With ISDs such as 30km for rural long-range scenario, we need valid channel models. Therefore, Nomor proposes to have a discussion to define a channel model for such distances.  In addition, we have shown in [26] that larger antenna heights than 35m significantly enhances the performance. Nomor asks RAN1 to discuss whether a larger antenna height, such as 75m, should be defined as the baseline assumption or if this height is considered too high for real-world scenarios. |
| Intel | In general, we are fine with the above proposal.  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. |
| 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.  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) |  | |
| Sierra Wireless | We are fine with above template. |
| 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. |
| Qualcomm | This link budget table is not our preferred template. We prefer to use a table similar to the link budget table presented in 36.824.  With regard to this table, we are concerned with the fields (5), and (11bis). They seem to suggest that a static beamforming/combining gain is assumed. As expressed earlier, we are concerned about such assumptions and would rather rely on link-level simulations to evaluate the actual gains that a cell-edge UE is likely to experience. We would prefer that these gains be reflected directly in (19a) and (19b).  Similarly, we need separate assumptions on (4) and (11) for rural and urban scenarios where antenna configurations are likely to be significantly different.  (21b) will also need to be examined carefully using link-level curves with and without HARQ. |

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

|  |  |  |
| --- | --- | --- |
| **Parameters and descriptions** | **Companies** | **Comments** |
| **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 | ZTE | 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. |
| Nomor Research GmbH | Nomor supports the 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. |
| Sierra Wireless | Option 1 |
| CATT | Option1 |
| Qualcomm | We propose Option 2: Incorporate beamforming/combining gains into link-level simulations  Receive array gain cannot be assumed to be a fixed constant. This is particularly important for cell-edge UEs where challenging channel conditions may make reliable channel estimation difficult, thereby decreasing the potential beamforming gains. In addition, Option 1 does not accurately reflect diversity gains from using a large number of TXRUs. We propose to incorporate beamforming/combining gain into link-level simulations where appropriate number of TXRUs are assumed at the receiver and realistic channel estimation and combining is taken into account. |
| **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 | ZTE | 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. |
| Nomor Research GmbH | Nomor supports the 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. |
| Sierra Wireless | Option 1 |
| CATT | Option 1 |
| Qualcomm | While we do not prefer to use this link budget template, we are okay with option 1 for this template. |
| **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 | ZTE | 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. |
| Nomor Research GmbH | Nomor supports the 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. |
| Sierra Wireless | Option 1 |
| CATT | Option 1 |
| Qualcomm | While we do not prefer to use this link budget template, we are okay with option 1 for this template. |
| **Lognormal shadow fading std deviation for control channel**   * Option 1: The same value in IMT-2020.   + Urban: 6 dB for NLOS O-to-I   + Rural: 8 dB for NLOS O-to-I, 8 dB for NLOS O-to-O   + Rural with long distance: 8 dB for LOS O-to-O   Option 2: Other values | ZTE | We are fine with Option 1 for link budget calculation. |
| Nokia/NSB | Option 2. The shadow fading standard deviation is associated with path loss model. Since, data and control channels use the same PL model, the standard deviation values for data and control channels should be the same.  Similar to the comment above for control channel, according to Tables A1-3 and A1-5 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: 6 dB for NLOS. * Rural: 8 dB for NLOS and 6 dB for LOS.   The corresponding slopes of PL models are:   * Urban: 43.42-3.1log10(hBS­­) for NLOS   Rural: 43.42-3.1log10(hBS­­) for NLOS and 40 for LOS |
| Nomor Research GmbH | Nomor supports the option 1. |
| Intel | Option 1 |
| Ericsson | These values should be determined according to the agreed scenarios with their channel models. |
| Sierra Wireless | Option 1 |
| CATT | Option 1 |
| Qualcomm | While we do not prefer to use this link budget template, we are okay with option 1 for this template. |
| **Shadow fading margin for control channel**   * Option 1: The same value in IMT-2020.   + Urban: 7.56 dB for NLOS O-to-I   + Rural: 8.45 dB for NLOS O-to-I, 10.45 dB for NLOS O-to-O   + Rural with long distance: 8.06 dB for LOS O-to-O * Option 2: Other values | ZTE | We are fine with Option 1 for link budget calculation. |
| Nokia/NSB | Option 2. 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 addition, it should be clarified that how to calculate the shadow fading margin for O2I and O2O since the standard deviation and slope is the same for both O2I and O2O, for a given PL model. |
| Nomor Research GmbH | Nomor supports the option 1. |
| Intel | Option 1 |
| Ericsson | These values should be determined according to the agreed scenarios with their channel models. |
| Sierra Wireless | Option 1 |
| CATT | Option 1 |
| Qualcomm | While we do not prefer to use this link budget template, we are okay with option 1 for this template. |
| **Lognormal shadow fading std deviation for data channel**   * Option 1: The same value in IMT-2020.   + Urban: 7 dB for NLOS O-to-I   + Rural: 8 dB for NLOS O-to-I, 8 dB for NLOS O-to-O   + Rural with long distance: 6 dB for LOS O-to-O   Option 2: Other values | ZTE | We are fine with Option 1 for link budget calculation. |
| Nokia/NSB | Option 2. The shadow fading standard deviation is associated with path loss model. Since, data and control channels use the same PL model, the standard deviation values for data and control channels should be the same.  Similar to the comment above for control channel, according to Tables A1-3 and A1-5 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: 6 dB for NLOS. * Rural: 8 dB for NLOS and 6 dB for LOS.   The corresponding slopes of PL models are:   * Urban: 43.42-3.1log10(hBS­­) for NLOS   Rural: 43.42-3.1log10(hBS­­) for NLOS and 40 for LOS |
| Nomor Research GmbH | Nomor supports the option 1. |
| Intel | Option 1 |
| Ericsson | These values should be determined according to the agreed scenarios with their channel models. |
| Sierra Wireless | Option 1 |
| CATT | Option 1 |
| Qualcomm | While we do not prefer to use this link budget template, we are okay with option 1 for this template. |
| **Shadow fading margin for data channel**   * Option 1: The same value in IMT-2020.   + Urban: 4.48 dB for NLOS O-to-I   + Rural: 5.13 dB for NLOS O-to-I, 6.61 dB for NLOS O-to-O   + Rural with long distance: 4.79 dB for LOS O-to-O * Option 2: Other values | ZTE | We are fine with Option 1 for link budget calculation. |
| Nokia/NSB | Option 2. 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 addition, it should be clarified that how to calculate the shadow fading margin for O2I and O2O since the standard deviation and slope is the same for both O2I and O2O, for a given PL model. |
| Nomor Research GmbH | Nomor supports the option 1. |
| Intel | Option 1 |
| Ericsson | These values should be determined according to the agreed scenarios with their channel models. |
| Sierra Wireless | Option 1 |
| CATT | Option 1 |
| Qualcomm | While we do not prefer to use this link budget template, we are okay with option 1 for this template. |
| **Penetration margin**   * Option 1: The same value in IMT-2020.   + Urban: 26.25 dB for NLOS O-to-I   + Rural: 9.00 dB for NLOS O-to-O, 12.50 dB for NLOS O-to-I   + Rural with long distance: 9.00 dB for LOS O-to-O * Option 2: Other values | 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 | Option 2 as follows: The values for O-to-I are the same as for Option 1, but the values for O-to-O apply only for high speed UEs, i.e., UEs inside vehicles (of any type). Penetration margin for low speed O-to-O UE should be 0 dB. |
| Nomor Research GmbH | Nomor supports the option 1. |
| Intel | Option 1 |
| Ericsson | These values should be determined according to the agreed scenarios with their channel models. |
| Sierra Wireless | Option 1 |
| CATT | Option 1 |
| Qualcomm | While we do not prefer to use this link budget template, we are okay with option 1 for this template. |
| **Other parameters** | ZTE | Assumptions on other parameters should be aligned with the conclusion from section 2.1.3. |
| Ericsson | We propose the scenarios listed in Appendix A4.1 |
|  |  |
|  |  |

1. **Link budget template in TR 36.824**

Reuse MCL calculation template employed in TR 36.824, some parameters identified with TBD (To Be Determined) in Table D need to be discussed and determined. In order to facilitate discussion on simulation assumptions based on MCL in TR 36.824, we have the following proposal:

**Proposal:**

* **For the link budget template in TR 36.824, adopt Table D for the baseline performance calculation for FR1.**

Table D MCL calculation template in TR 36.824 for FR1

|  |  |
| --- | --- |
| **Parameters** | **Value** |
| **Transmitter** | |
| (1) Tx power (dBm) | 23 |
| **Receiver** | |
| (2) Thermal noise density (dBm/Hz) | -174 |
| (3) Receiver noise figure (dB) | TBD |
| (4) Interference margin (dB) | TBD |
| (5) Occupied channel bandwidth (Hz) | TBD |
| (6) Effective noise power  = (2) + (3) + (4) + 10 log(5) (dBm) | - |
| (7) Required SINR (dB) | Obtained from link-level simulations |
| **(8)** **Receiver sensitivity**  = (6) + (7) (dBm) | - |
| **(9)** **MCL**  = (1) − (8) (dB) | - |

Companies are invited to provide views on the above proposal.

|  |  |
| --- | --- |
| **Companies** | **Comments** |
| Intel | 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. |
| NTT DOCOMO | We propose to add “Tx antenna gain (dBi)”, “Rx antenna gain (dBi)”, (Implementation margin (including cable/body loss) (dB)), (Shadow fading margin), and (Penetration margin (dB)) for clarification. On the other hand, we don’t intend to define common parameter for the study, so companies can use their own parameters. |
| SoftBank | We are fine with this proposal.  We can discuss further regarding the necessity of antenna gain in this table. |
| Qualcomm | We support this proposal. An MCL-focused link budget is straightforward and provides the necessary insight. We would like to emphasize that we do not want to assume constant/fixed/static beamforming/combining gains in our link budget analysis. Link-level simulations should take into account realistic beamforming gains and this should be implicitly factored into the required SINRs for each PHY channel. |

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

|  |  |  |
| --- | --- | --- |
| **Parameters and descriptions** | **Companies** | **Comments** |
| Receiver noise figure (dB) | Intel | Can be based on IMT submission template, i.e., 5dB at BS and 7dB at UE. |
| Ericsson | gNB: 5 dB; UE: 7 dB |
| NTT DOCOMO | We can follow the IMT 2020, 5dB for BS and 7 dB for UE |
| InterDigital | gNB : 5dB; UE: 9dB, following TR 38.802 |
| Qualcomm | We propose 5 dB for gNB and 7 dB for UE |
| Interference margin (dB) | Intel | 0dB can be assumed as it is for coverage enhancement study. |
| Ericsson | These values should be determined according to the agreed scenarios with their channel models. |
| NTT DCOOMO | We prefer to consider the interference margin, e.g. 2 dB, since the study is for cell edge. |
| Qualcomm | We acknowledge the difficulty of choosing appropriate margins. To take this discussion forward, we propose to reuse the receiver interference density values used in IMT-2020.  For control channel:  -161.70 dBm/Hz for UL, -169.30 dBm/Hz for DL.  For data channel  -165.70 dBm/Hz for UL, -169.30 dBm/Hz for DL. |
| Occupied channel bandwidth (Hz) | Intel | This depend on the simulated channels. Similar values can be considered as for IMT submission template. |
| Ericsson | 700 MHz: 20 MHz (10 MHz simulated; FDD)  4 GHz: 400 MHz (100 MHz simulated; TDD) |
| NTT DOCOMO | It’s up to the number of RBs, so the appropriate number may be used accordingly. |
| Qualcomm | Occupied channel bandwidth should reflect the number of occupied PRBs. This applies to all PHY channels under consideration. |
| Other parameters | Ericsson | See Appendix A4.1 |
| NTT DOCOMO | We need to define BS Tx power for DL as well. |
| SoftBank | Agree with DOCOMO |

2.1.5 Other channels for FR1

The channel-specific parameters for other channels, e.g. PDSCH, PDCCH, PRACH, Msg3, SSB/PBCH, are summarized based on companies’ input in Appendix 3.

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

|  |  |  |
| --- | --- | --- |
| **Channel** | **Companies** | **Comments** |
| PDSCH | ZTE | Reusing simulation assumptions as PUSCH except for the waveform which should be OFDM. |
| Nokia/NSB | In our view, full bandwidth allocation and lowest possible MCS index should be assumed for coverage study. The same observations we made on PUSCH on the TDD frame structure apply for PDSCH. |
| Nomor Research GmbH | We have observed in our simulation results [26] for rural long distance scenario that PDSCH performance meets the 1Mbps throughput criterion defined in SID. Therefore, Nomor believes that is not necessary to further investigate PDSCH on coverage enhancement. |
| Intel | The same evaluation methodology and simulation assumption for PUSCH can be considered. In particular, TBS/MCS/the number of PRBs/symbols can be determined for deployment scenario and frame structure.  Based on our simulation results, we do not see the need for PDSCH coverage enhancement in FR1. |
| Ericsson | 700 MHz:   * Link and rank adaption based on 20 slot wideband CSI feedback periodicity and HARQ with up to three retransmissions. 52 PRBs, 2 symbols with DMRS, PDSCH and DMRS mapped to 12 symbols (2 symbols reserved for PDCCH), * overhead due to CSI-RS and TRS with 20ms period * 10% BLER   4 GHz:   * Link and rank adaption based on 20 slot wideband CSI feedback periodicity and HARQ with up to three retransmissions. 273 PRBs, 2 symbols with DMRS, PDSCH and DMRS mapped to 12 symbols (2 symbols reserved for PDCCH), * overhead due to CSI-RS and TRS with 20ms period * 10% error rate |
| NTT DCOOMO | The same simulation assumption for PUSCH may be used with considering the TDD configuration and different target data rate (which may affect to number of RB and MSC). |
| CATT | Based on our simulation results which shown in R1-2003652, PDSCH is not the bottleneck. |
| Qualcomm | Table 6 in our tdoc lists the set of parameters used for PDSCH. Full band allocations are assumed with at least 3 DMRS symbols and 9 data symbols. Most importantly, we use closed-loop beamforming based on SRS transmissions to accurately model beamforming gains seen by a cell-edge UE. Unicast PDSCH is not seen to be a bottleneck. |
| PDCCH | ZTE | AL: 8 or 16;  Payload: 40 bits for fallback DCI, 30 bits for compact DCI. |
| Nokia/NSB | AL16, DCI payload size 40 bits, 2 OFDM symbols and CORESET bandwidth 48 PRBs is our preferred configuration. |
| Nomor Research GmbH | We have observed in our simulation results that PDCCH coverage performance is sufficient in the rural long distance scenario **エラー! 参照元が見つかりません。**. Therefore, Nomor believes that it is not necessary to further investigate PDCCH on coverage enhancement. |
| Intel | AL 8. Payload size = 40 bits.  CORESET size = 2 symbols and 48 PRBs. |
| Ericsson | 700 MHz:   * PDCCH using aggregation level 16 and DCI format 0\_0 or 1\_0 with payload of 39bits+24bits CRC * CORESET 48 PRBs, 2 symbols, non-interleaved mapping, * precoder cycling * 1% and 10% error rate   4 GHz:   * PDCCH using aggregation level 16 and DCI format 0\_0 or 1\_0 with payload of 44bits+24bits CRC * CORESET 273 PRBs, 2 symbols, non-interleaved mapping, * precoder cycling * 1% and 10% error rate |
| NTT DOCOMO | AL : 16, payload size = 24 bits. |
| CATT | Based on our simulation results which shown in R1-2003652, PDCCH is not the bottleneck. |
| Qualcomm | As mentioned in our tdoc, we assumed AL8 PDCCH with a payload of 40 bits( + 24 bit CRC). Most critical in this evaluation is the beamforming gain assumed for broadcast PDCCH. We believe that in a MMIMO setup, broadcast PDCCH is unable to take advantage of beamforming gains available to unicast transmissions and therefore can become a potential bottleneck. |
| PRACH | ZTE | NR PRACH preamble format 1 and format 2 are prioritized. |
| Nokia/NSB | We propose to include C2 preamble in the study. |
| Intel | For FR1, PRACH format 0 is assumed.  Performance metric is 1% miss detection probability with 0.1% false alarm target. |
| Ericsson | 700 MHz:   * Format 0 * 10% and 1% missed detection at 0.1% false alarm probability, with maximum timing estimation error 50% of the normal CP length and 64 preambles per cell * Initial timing offset uniformly distributed in [0, 23 µs] corresponding to 6 km intersite distance (ISD).   4 GHz:   * Format B4 (12 symbols) * 10% and 1% missed detection at 0.1% false alarm probability, with maximum timing estimation error 50% of the normal CP length and 64 preambles per cell * Initial timing offset uniformly distributed in [0, 1.9 µs] for 500 m ISD and [0, 6.7 µs] 1732 m ISD |
| Qualcomm | As mentioned in our tdoc, we assumed format B4 for RACH spanning 12 symbols and having a sequence length of 139. No significant issues were identified. |
| Msg3 | 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 bits optional). |
| 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 | 700 MHz:   * 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. * 1% and 10% error rate   4 GHz:   * 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. * 1% and 10% error rate |
| Qualcomm | As mentioned in our tdoc, we assumed a PUSCH transmission with 2-4 RB allocation to carry msg3 payload of size 56 or 72 bits. Lack of repetition of msg3 becomes a bottleneck especially when considering voice services. |
| SSB/PBCH | ZTE | A combination of 4 SSBs in 80 ms is assumed |
| Intel | 4 SSB combinations in TTI with 80ms. |
| Ericsson | 700 MHz:   * SSB transmitted with 20ms periodicity * 10% and 1% residual BLER after 4 retransmissions within MIB TTI of 80ms, UE is not assumed to know the SS/PBCH block index, wideband precoder, cycled for different transmissions   4 GHz:   * SSB 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   1% and 10% error rate |
| Qualcomm | As mentioned in our tdoc, typical assumptions on transmission of SSB/PBCH with the receiver potentially combining more than one instance of SSB to improve performance. No significant issues were identified. |
| Other channels | Ericsson | **MSG2:**  700 MHz:   * PDSCH with 8 bytes payload, * MCS 0 with transport block scale factor 0.25, 12 PRBs, * DMRS symbol, 9 symbols with PDSCH * (and 2 symbols reserved for PDCCH) * precoder cycling * 1% and 10% error rate   4 GHz:   * PDSCH with 8 bytes payload, * MCS 0 with transport block scale factor 0.25, 12 PRBs, * DMRS symbol, 9 symbols with PDSCH * (and 2 symbols reserved for PDCCH) * precoder cycling * 1% and 10% error rate |
|  |  |
|  |  |

2.1.6 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** |
| ZTE | Directly setting a target based on Option 1 or Option 2 would be a bit subjective. So, 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).  If Option 1 is chosen, our preference is follows.   * Urban: Target ISD = 400/500m * Rural: Target ISD = 1732/6000m * Rural with long distance: Target ISD = 12km/30km   If Option 2 is chosen, the target MCL can be derived by the coverage gap between LTE coverage at 2GHz and NR coverage at 4GHz. The reasoning is that, to make sure of the same gNB sites for NR and LTE, we have to make sure the coverage of NR is not less than the coverage of LTE. |
| Nokia/NSB | Option 1. It would seem more reasonable to first agree/align on the EVM and simulation assumptions and then discuss ISD targets. |
| Nomor Research GmbH | Nomor supports option 1, based on target ISDs:   * + Urban: ISD = 400/500m   + Rural: ISD = 1732/6000m   + Rural with long distance: ISD = 30km |
| 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, we share similar view as ZTE that target ISD needs to be first determined for coverage analysis. |
| 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.** |
| NTT DOCOMO | We prefer Option 2 and to use relative values for the target performance (e.g. improvement of the worst channels need to be considered), since it may be difficult to define common values for the assumption and it may be difficult to discuss the absolute values. |
| CATT | Support |
| InterDigital | We support Option 2. |
| SoftBank | We support option 2  As discussed in our contribution, MCL=147dB should be adopted for voice.  In our understanding, this discussion is very important to make NR more successful. The input from operators therefore should be carefully investigated. We don’t see a strong necessity to decide an exact target value at this meeting, and hence we prefer to continue discussion. |
| Qualcomm | We propose Option 3: Target MCL and relative MCL differences are considered as performance metrics.  Choice of ISDs and the corresponding target pathloss values do not reflect real world deployments that tend to have large variabilities. To use this number as a hard cut off for coverage enhancement does not seem like the right approach. They can sometimes point to large shortfalls in coverage and in other instances can falsely suggest that no coverage issues exist.  We prefer to focus on relative gaps that may exist between the various PHY channels and aim to bridge these gaps to the extent possible. In particular, bridging any gap that may exist between uplink and downlink control channels is important to ensure basic call stability. Additionally, any effort to extend the coverage meeting minimum data rate requirements is also valuable. |

# 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. R1-2003832 Work plan for Study on NR coverage enhancements China Telecom
5. R1-2003833 Draft skeleton of TR 38.830 Study on NR coverage enhancements China Telecom
6. R1-2004155 Overview of coverage enhancement: scenarios, channels, services and potential solutions Huawei, HiSilicon
7. R1-2004631 General Considerations for the Coverage Enhancement Study Ericsson
8. R1-2003648 Discussion on the methodology for coverage enhancement CATT
9. R1-2003919 Assumptions for NR coverage evaluation vivo
10. R1-2004027 Discussion on evaluation for coverage enhancement LG Electronics
11. R1-2004377 Considerations for Coverage Enhancement Indian Institute of Tech (H)
12. R1-2004632 Evaluation Methodology for Coverage Enhancements Ericsson
13. R1-2003298 Baseline coverage performance for FR1 Huawei, HiSilicon
14. R1-2003338 Discussion on baseline coverage performance for FR1 ZTE
15. R1-2003342 NR Coverage requirements and simulation assumption for FR1 Sierra Wireless, S.A.
16. R1-2003435 Evaluation on NR coverage performance for FR1 vivo
17. R1-2003464 Requirements for Voice coverage enhancements with FR1 SoftBank Corp.
18. R1-2003649 Discussion on the baseline performance and simulation assumptions of coverage enhancement for FR1 CATT
19. R1-2003683 Discussion on scenarios for FR1 baseline performance evaluation MediaTek Inc.
20. R1-2003773 Discussion on baseline coverage performance for FR1 Intel Corporation
21. R1-2003778 Downlink coverage in FR1 Charter Communications, Inc
22. R1-2003816 Discussion on evaluation methodologies for baseline coverage performance analysis Panasonic Corporation
23. R1-2003821 Baseline evaluation for NR UL coverage enhancement Lenovo, Motorola Mobility
24. R1-2003834 Evaluation methodology and preliminary baseline performance for NR coverage enhancements China Telecom
25. R1-2003914 Scenarios and simulation assumptions for coverage enhancement in FR1 Samsung
26. R1-2003940 Simulation Assumptions and Baseline Coverage for FR1 Nomor Research GmbH, Facebook
27. R1-2003970 Discussion on coverage enhancements in FR1 CMCC
28. R1-2004108 NR coverage performance for FR1 OPPO
29. R1-2004178 Baseline coverage evaluation of UL and DL channels – FR1 Nokia, Nokia Shanghai Bell
30. R1-2004196 On NR coverage analysis in FR1 Sony
31. R1-2004249 On baseline coverage performance for FR1 Apple
32. R1-2004304 Simulation assumptions and throughput performance for UL in FR1 InterDigital, Inc.
33. R1-2004338 Preliminary evaluation for FR1 Urban scenario Sharp
34. R1-2004352 Simulation Parameters and Initial Results for FR1 Ericsson
35. R1-2004424 Baseline coverage performance for FR1 NTT DOCOMO, INC
36. R1-2004497 Baseline FR1 coverage performance Qualcomm Incorporated
37. R1-2004540 Baseline coverage performance for FR1 xiaomi

# Appendix

## Appendix 1

Appendix 1 Companies’ views on simulation assumptions for PUSCH for FR1

|  |  |
| --- | --- |
| Parameters | Companies’ views |
| Scenario and frequency | * Urban:   + 4GHz(TDD) (China Telecom, Huawei, HiSilicon, Sharp, Panasonic, MTK, Lenovo, Samsung, Sony, xiaomi, Qualcomm, Intel, OPPO, vivo, CATT, Nokia, Nokia Shanghai Bell, Ericsson, ZTE)   + 2.6GHz(TDD) (CMCC) * Rural:   + 4GHz(TDD) (China Telecom, Huawei, HiSilicon, MTK, Lenovo, Samsung, xiaomi, vivo, CATT, Nokia, Nokia Shanghai Bell, ZTE)   + 2GHz(FDD) (China Telecom, Huawei, HiSilicon, MTK, Lenovo, Samsung, OPPO, vivo, CATT, ZTE)   + 700MHz(FDD) (Panasonic, Qualcomm, Intel, Nokia, Nokia Shanghai Bell, Ericsson, ZTE) * Rural with long distance:   + 700MHz (FDD) (China Telecom, Huawei, HiSilicon, Panasonic, MTK, Lenovo, Samsung, Qualcomm, OPPO, vivo, CATT, ZTE) |
| Frame structure for TDD | * Option 1: DDDSU (10D:2G:2U) (Nokia, Nokia Shanghai Bell, OPPO, xiaomi, Samsung) * Option 2: DDDSUDDSUU (10D:2G:2U) (China Telecom, Huawei, HiSilicon, vivo, CATT, MTK, Lenovo, OPPO, xiaomi, Samsung) * Option 3: DDDDDDDSUU (CMCC) * Option 4: 4D1S5U (periodicity 5ms for 30kHz SCS) (D:U=10:2 for S slot) (Nokia, Nokia Shanghai Bell) * Option 5: DDSU (S is 11DL:1G:2UL) 2ms periodicity (Qualcomm) * Option 6: DSUUD (Sony) |
| BLER | For PUSCH:   * + 10% iBLER for eMBB (China Telecom, Huawei, HiSilicon, Sharp, Panasonic, Samsung, Intel, Nokia, Nokia Shanghai Bell, ZTE)   + 2% rBLER for VoIP (Panasonic, Nokia, Nokia Shanghai Bell, InterDigital, Samsung, ZTE)   + eMBB scenarios = 10% BLER and optionally 40% BLER, Voice scenario = 1% BLER (Sierra Wireless)   + 10% BLER for eMBB service and 1% BLER for VoIP service (Lenovo) |
| Codec for voice | * Option 1: 7.2 kbps (Sierra Wireless) * Option 2: 12.2 kbps (China Telecom, Huawei, HiSilicon, ZTE, CATT, Lenovo, OPPO, Apple, Samsung, MTK, NTT DOCOMO) * Option 3: AMR-WB 12.65 kbps (Nokia, Nokia Shanghai Bell) * Option 4: EVS 13.2 kbps (Sierra Wireless, Softbank, Qualcomm) |
| Pathloss model (select from LoS or NLoS) | * Urban/rural:   + NLOS (China Telecom, Huawei, HiSilicon, ZTE, vivo, MTK, Lenovo, Samsung, OPPO, Sharp, xiaomi, CATT) * Rural with long distance:   + LOS (China Telecom, Huawei, HiSilicon, ZTE, vivo, MTK, Lenovo, Samsung)   + NLOS (OPPO) |
| Channel model for link-level simulation | Channel model for TDL:   * Urban:   + TDL-C (China Telecom, Huawei, HiSilicon, ZTE, vivo, CATT, MTK, Lenovo, Samsung, Panasonic, OPPO, Apple, Nokia, Nokia Shanghai Bell, InterDigital, Sierra Wireless, xiaomi, NTT DOCOMO)   + TDL-A (Intel, Panasonic, Ericsson, Apple) * Rural:   + TDL-C (China Telecom, Huawei, HiSilicon, ZTE, vivo, CATT, MTK, Lenovo, Samsung, Panasonic, OPPO, Nokia, Nokia Shanghai Bell, InterDigital, Sierra Wireless, xiaomi, NTT DOCOMO)   + TDL-A (Intel, Panasonic, Ericsson) * Rural with long distance:   + TDL-E (Huawei, HiSilicon)   + TDL-D (China Telecom, ZTE, vivo, CATT, MTK, Lenovo, Samsung)   + TDL-C (Panasonic, OPPO)   + TDL-A (Intel, Panasonic)   Channel model for CDL:   * + CDL-A (Sharp)   + CDL-C/E (Qualcomm) |
| Delay Spread | * Urban:   + 616ns (InterDigital)   + 363ns (Qualcomm, Nokia, Nokia Shanghai Bell)   + 300ns (China Telecom, Huawei, HiSilicon, vivo, ZTE, MTK, Lenovo, Samsung, OPPO, xiaomi, Ericsson, Apple)   + 240ns (CATT, Panasonic)   + 100ns (Ericsson)   + 30ns (Intel, Apple) * Rural:   + 363ns (Panasonic)   + 300ns (China Telecom, Huawei, HiSilicon, vivo, ZTE, MTK, Lenovo, Samsung, OPPO, xiaomi, Apple)   + 153ns (InterDigital)   + 100ns (Ericsson)   + 37ns for NLOS O2O, 34ns for NLOS O2I (CATT)   + NLOS 37ns, LOS 32ns (Qualcomm)   + 37ns (Nokia, Nokia Shanghai Bell)   + 30ns (Intel, Apple, Ericsson) * Rural with long distance:   + 363ns (Panasonic)   + 300ns (China Telecom, Huawei, HiSilicon, vivo, CATT, MTK, Lenovo, Samsung, OPPO, Apple)   + 37ns (Qualcomm, Nokia, Nokia Shanghai Bell)   + 30ns (ZTE, Intel, Apple) |
| UE velocity | * + 3km/h for indoor, 120km/h for outdoor (China Telecom, Huawei, HiSilicon, ZTE, vivo, CATT, MTK, Lenovo, Samsung, OPPO, Qualcomm)   + 3km/h for eMBB, 3km/h, 30km/h, 100km/h for VoIP (Sierra Wireless)   + 3km/h (Intel, Panasonic)   + 3km/h, [30km/h] for 4GHz, 3km/h, [30,120km/h] for 700MHz (Ericsson)   + 3km/h, 30km/h, for urban, 3km/h, 120km/h for rural. (Nokia, Nokia Shanghai Bell) |
| Occupied channel bandwidth | * Urban:   + eMBB:   + 40PRBs (xiaomi)   + 30PRBs (China Telecom, Huawei, HiSilicon, vivo, CATT, MTK, Lenovo, Samsung, OPPO, xiaomi)   + 20PRBs (xiaomi, Sierra Wireless)   + 15PRBs (NTT DOCOMO)   + 6PRBs (Intel)   + 4PRBs (Sharp)   + VoIP:   + 4PRBs (China Telecom, Huawei, HiSilicon, vivo, CATT, MTK, Lenovo, Samsung, OPPO, NTT DOCOMO)   + 1PRB (Sierra Wireless) * Rural/rural with long distance:   + eMBB:   + 4PRBs (China Telecom, Huawei, HiSilicon, vivo, CATT, MTK, Lenovo, Samsung, OPPO, xiaomi)   + 2PRBs (NTT DOCOMO, Intel, Sierra Wireless)   + VoIP:   + 4PRBs (China Telecom, Huawei, HiSilicon, vivo, CATT, MTK, Lenovo, Samsung, OPPO)   + 2PRBs (Intel)   + 1PRB (Sierra Wireless) |
| BS antennas configuration | * Urban:   + 192 elements and 2 TxRU (China Telecom, Huawei, HiSilicon, vivo, Lenovo, Samsung, OPPO)   + 192 elements and 4/8/64 TxRU (ZTE)   + 64 elements and 2 Rx (Nokia, Nokia Shanghai Bell)   + 32 elements and 4 Rx (Ericsson)   + 16 Rx (Sierra Wireless)   + 8 Rx (Apple)   + 4 Rx (Panasonic)   + 2 Rx (Intel, InterDigital, xiaomi) * Rural/rural with long distance:   + 64 elements and 2 TxRU (China Telecom, Huawei, HiSilicon, vivo, Lenovo, Samsung, OPPO)   + 64 elements and 2/4/8 TxRU (ZTE)   + 32 elements and 2 TxRU (Ericsson, Nokia, Nokia Shanghai Bell) |
| UE antennas configuration | * Urban:   + 1T (vivo, Intel, InterDigital, Sierra Wireless, Apple, Ericsson, Nokia, Nokia Shanghai Bell)   + 2T (China Telecom, ZTE, Lenovo, Samsung, OPPO, Huawei, HiSilicon, Panasonic, xiaomi) * Rural:   + 1T (China Telecom, ZTE, Lenovo, Samsung, OPPO, vivo, Intel, InterDigital, Sierra Wireless, Apple, Ericsson, Nokia, Nokia Shanghai Bell, xiaomi)   + 2T (Huawei, HiSilicon, Panasonic) * Rural with long distance:   + 1T (China Telecom, ZTE, Lenovo, Samsung, OPPO, Huawei, HiSilicon, vivo, Intel, InterDigital, Sierra Wireless, Apple)   + 2T (Panasonic) |
| DMRS configuration | * For 3km/h:   + 1 DMRS symbol (China Telecom, Huawei, HiSilicon, ZTE, vivo, Lenovo, Samsung, OPPO, MTK, CATT)   + 2 DMRS symbol (MTK, Sierra Wireless) * For 120km/h:   + 2 DMRS symbol (one front- loaded and one additional) (China Telecom, Huawei, HiSilicon, ZTE, vivo, Lenovo, Samsung, OPPO, Sierra Wireless, CATT)   + 3 DMRS symbol (MTK)   Type 1 with 3 symbols with no data on DMRS symbols (Qualcomm)  2 DMRS symbols (Intel, Nokia, Nokia Shanghai Bell) |
| Repetition | * For eMBB   + On (LG)   + Off (Sierra Wireless) * For VoIP   + On (InterDigital, Sierra Wireless, LG)   + Off |
| Frequency hopping | * + On (InterDigital, Sierra Wireless, Intel)   + Off (NTT DOCOMO) |
| Shadow fading margin | * Urban: 4.48 dB (China Telecom, Huawei, HiSilicon, OPPO) * Rural: 5.13 dB for O-to-I, 6.61 dB for O-to-O (China Telecom, Huawei, HiSilicon, OPPO) * Rural with long distance: 4.79 dB (China Telecom, Huawei, HiSilicon, OPPO); 8dB for 2.6GHz (CMCC) |
| Penetration margin | * Urban: 26.25 dB (Sharp, China Telecom, OPPO) * Rural: 9.00 dB for O-to-O, 12.50 dB for O-to-I (China Telecom, OPPO) * Rural with long distance: 9.00 dB (China Telecom, OPPO) * Rural at 4GHZ for NLoS O2I: 14.53 dB (Huawei, HiSilicon); 15dB for 2.6GHz (CMCC) |

## Appendix 2

Appendix 2 Companies’ views on simulation assumptions for PUCCH for FR1

|  |  |
| --- | --- |
| Parameters | Companies’ views |
| Format type | * Format 1   + 2bits (China Telecom, Huawei, HiSilicon, Lenovo, Samsung, OPPO, Sharp)   + 1bit (CATT) * Format 1 and Format 3   + Format 1 or 3, 1bit, 2bits, 6bits, 11bits, 22bits. (ZTE)   + Format 1, 2bits; Format 3, 8bits. (vivo)   + Format 1 for VoIP with 1bit UCI, Format 3 for eMBB with 8bits UCI. (NTT DOCOMO)   + Format 1, UCI size = 1 bit; Format 3, UCI size = 50 bits (Intel)   + Format 1 with 2 bits UCI and Format 3 with 20 bits UCI (Nokia, Nokia Shanghai Bell)   + PUCCH format 1(1bit), PUCCH format 3 (19bits, + 9bits CRC) (Qualcomm) |
|  Occupied channel bandwidth | 1 PRB (China Telecom, Huawei, HiSilicon, ZTE, vivo, CATT, Intel, Lenovo, OPPO, Sharp, Samsung, Qualcomm)  1 PRB for VoIP, 8 PRBs for eMBB (NTT DOCOMO) |
| BS antennas configuration | * Urban:   + 192 elements and 2 TxRU (China Telecom, Huawei, HiSilicon, Lenovo, OPPO)   + 2/4/8/64 TxRU (ZTE) * Rural and rural with long distance:   + 64 elements and 2 TxRU (China Telecom, Huawei, HiSilicon, Lenovo, OPPO)   + 2/4 TxRU (ZTE) |
| UE antennas configuration | * + 1T (China Telecom, ZTE, CATT)   + 2T for urban and rural, 1T for rural with long distance (Huawei, HiSilicon)   + 2T for urban, 1T for rural and rural with long distance (Lenovo, OPPO) |
| Repetition | * + On (LG, CATT)   + Off |
| Frequency hopping | * + On (Intel, CATT)   + Off |
| Shadow fading margin | * Urban: 7.56 dB * Rural: 8.45 dB for O-to-I, 10.45 dB for O-to-O * Rural with long distance:   + 8.06 dB (China Telecom)   + 6 dB (Huawei, HiSilicon) |

## Appendix 3

Appendix 3 Companies’ views on simulation assumptions for other channels for FR1

|  |  |  |  |
| --- | --- | --- | --- |
| Other channels | Company | Key parameters | |
| PDCCH | Huawei, HiSilicon | Aggregation level: 8, DCI payload size: 60 bits  CRC length: 24 bit, CORRESET PRB: 48, CORRESET symbols: 2  Channel model: TDL-C, Moving speed: 3km/h & 120km/h  DMRS overhead: 1 front-loaded DMRS, 1 front loaded DMRS + 1 additional DMRS | |
| Sharp | Aggregation level: 16, DCI payload size: 64 bits including CRC | |
| Panasonic | 1% BLER | |
| Samsung | DCI format 1-0/0-0, DCI size = 68 bit; QPSK, aggregation level = 16 CCE | |
| Qualcomm | Number of UE Rx antennas: 2, BW=48 RBs  PDCCH aggregation level: 8, DCI size=40 (+ 24 bits CRC)  PDCCH interleaving: Enabled, REG bundle size=6  Beam forming: Broadcast (precoder cycling), Unicast (SRS-based precoding)  Number of control symbols: 2 | |
| Intel | DCI size = 40 bits, Aggregation level = 4,  CORESET size in time = 2 symbols, CORESET size in frequency = 48 PRBs | |
| vivo | Format type: CCE0 AL=8 DCI size = 39bits  Occupied channel bandwidth: 48RB | |
| CATT | Payload size (include 24 bits CRC) 64bits, Length of PDCCH=2 OS | |
| Nokia | Aggregation level 16 with 40 bits DCI and 24 bits CRC.  A CORESET bandwidth of 48 PRBs and two OFDM symbols are used. | |
| ZTE | DCI payload (excluding 24bits CRC), 40 bits for fallback DCI, 30 bits for compact DCI  Transmission type: Interleaved (R=3 for 3OS,others,R=2)  REG bundling size=6  Antenna configuration: 4T4R for urban, 2T2R for rural. | |
| NTT DOCOMO | 1% BLER, 48 RBs | |
| PDSCH | Huawei, HiSilicon | MCS: 2 (2,251/1024), Scheduled PRB: Calculated  Channel model: TDL-C, Moving speed: 3km/h & 120km/h  DMRS overhead: 1 front-loaded DMRS, 1 front loaded DMRS + 1 additional DMRS | |
| Sharp | 12 OFDM symbols, MCS 7 | |
| Panasonic | 10 % iBLER for PDSCH | |
| NTT DOCOMO | 2% rBLER,  1 RB for VoIP, 40 RBs for eMBB (OtoI), 4 RBs for eMBB (rural) | |
| Qualcomm | Slot structure: 2 symbol PDCCH, 9 symbols PDSCH, 2 symbol guard/PUCCH/PUSCH, 1 symbol SRS  SRS configuration: Wideband SRS transmission from 2 physical antenna (out of the 4)  PDSCH DMRS : Type 1 with 3 symbols with Data and DM-RS TDMed on the DM-RS symbols  Precoding Closed Loop (CL): SVD-based precoding every 4 PRBs based on the SRS transmission | |
| Intel | For Rural scenario: TBS = 1032, MCS = 4, 14 PRBs, 12 symbols  For Urban scenario: TBS = 5120, MCS = 10, 32 PRBs, 12 symbols  2 DMRS symbols (4th and 10th symbol) | |
| vivo | Occupied channel bandwidth:  82RB for urban, 8RB for rural TDD, 11RB for rural FDD, 4RB for VoIP  DMRS configuration: Type I, two DMRS symbol, no multiplexing with data | |
| Nokia | For PDSCH, 2 OFDM symbols for DMRS are used in Rural and Suburban scenarios, where high-speed UEs (120 Km/h) are also considered.1 OFDM symbol is used for DMRS for PDSCH in the remaining scenarios. | |
| CATT | Length of DMRS = 1 OS,  Occupied channel bandwidth: 51PRBs for TDD, 106 PRBs for rural | |
| Samsung | eMBB: 10/1 (Urban/Rural) Mbps,  VoIP: 12.2kbps (304bits: 244 + 60 (header for RoHC compress)) | |
| Msg3 | Huawei, HiSilicon | MCS: 0 (2,120/1024), Scheduled PRB: 2, Payload size: 56 bits  Channel model: TDL-C, Moving speed: 3km/h & 120km/h  DMRS overhead: 1 front-loaded DMRS, 1 front loaded DMRS + 1 additional DMRS | |
| Qualcomm | Msg3 payload size: {56, 72} bits | |
| PRACH | Qualcomm | Urban:  Format B4, Sequence length=139,  30kHz SCS, 0.1% false alarm, 1% miss-detection | Rural:  Format 1, Sequence length=839  1.25 kHz SCS, 0.1% false alarm, 1% miss-detection |
| vivo | PRACH format B4, Occupied channel bandwidth: 12RB | |
| ZTE | Miss-detection target: 1%  Preamble:  NR PRACH preamble format 2 with Ncs = 167, Logical sequence index = 22, v=2 for O2I  NR PRACH preamble format 1 with Ncs = 202, Logical sequence index = 384, v=0 for O2O | |
| Intel | PRACH format 0, 0.1% false alarm target | |
| SSB/PBCH | Qualcomm | For SSS/PSS:  # of Rx: 2, Bandwidth=12 RBs  30kHz SCS, Frequency offset=5ppm  1% false alarm, 10% miss-detection | For PBCH:  # of Rx: 2, Bandwidth=20 RBs  30kHz SCS, 1% BLER  Frequency offset=0.05ppm |
| Intel | PBCH related parameters: 4 accumulations | |
| ZTE | PBCH payload (excluding 24bits CRC): 32 bits  Combined number: 4 SSBs  Frequency Offset:   * + Initial acquisition   + TRP: uniform distribution +/- 0.05 ppm   + UE: uniform distribution +/- 5, 10, 20 ppm (each company to choose one)   + Non-initial acquisition   + TRP: uniform distribution +/- 0.05 ppm   + UE: uniform distribution +/- 0.1 ppm | |
| vivo | PBCH format: 4-shot combining, Occupied channel bandwidth: 20RB | |

## Appendix 4: Scenarios and Channel Parameter Details

## A4.1 Proposal 1

Table A4.1.1 Scenario for 700MHz.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | Rural | LMLC | Extreme Rural |
| Layout | Macro layer: Hex. Grid | | |
| Inter-BS distance | 7km | 6km | 173km |
| Carrier frequency | 700MHz | | |
| Aggregated system  bandwidth | 20MHz(DL+UL) | | |
| Simulation bandwidth | 10MHz (FDD) | | |
| Channel model | RMa\_B from ITU M.2412 | LMLC from ITU M.2412 | 3GPP Extreme Long Range from 38.802 |
| BS Tx power | 43dBm | | |
| UE Tx power | 23dBm | | |
| BS antenna configurations & gain, including RF losses | Sector antenna  (M,N,P,Mg,Ng) = (8,1,2,1,1) or (8,2,2,1,1) ; (4x1 virtualization)  2 or 4 TxRUs; 17 or 20dBi max gain  Follow the modeling of ITU M.2412 | | |
| tilt:3 deg | tilt:6 deg | tilt:0 deg |
| BS antenna height | 35m | | |
| BS receiver noise figure | 5dB | | |
| UE antenna configuration | 1T2R | | |
| UE antenna height | Follow the modeling of ITU M.2412 | | |
| UE antenna gain | Isotropic, 0dBi | | |
| UE receiver noise figure | 7dB | | |
| Traffic model | Companies specify if full buffer or non full buffer is used when determining SINR statistics. | | |
| Traffic load (Resource utilization) | See Table A4.1.2 | | |
| UE distribution | 50% outdoor vehicles (120km/h) and 50% indoor (3km/h)  User distribution: Uniform | |  |

Table A4.1.2. Desired and interfering signal assumptions for 700MHz.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Channel** | **Desired signal beam** | **Interfering signal** | **Interferer activity** | **Power control SNR target (P0)** |
| **SSB** | sector | SSB | 1.0 |  |
| **Msg2 Pdcch** | sector | PDSCH | 0.5 |  |
| **Msg2 Pdsch** | sector | PDSCH | 0.5 |  |
| **PDCCH** | Sector | PDSCH | 0.5 |  |
| **PDSCH data** | sector | PDSCH | 0.5 |  |
| **Msg 1 PRACH** | sector | PUSCH | 0.5 | 3dB (P0=-116) |
| **PUCCH** | sector | PUCCH | 0.5 | 3dB (P0=-113) |
| **Msg3 PUSCH** | sector | PUSCH | 0.5 | 10dB (P0=-106) |
| **CSI PUSCH** | sector | PUSCH | 0.5 | 10dB (P0=-106) |
| **PUSCH Data** | sector | PUSCH | 0.5 | 10dB (P0=-106) |

Table A4.1.3 Channel configurations for 700MHz

|  |  |
| --- | --- |
| **Channel/Signal** | **Assumptions** |
| **Initial Access** | |
| SSB (P/S-SS and PBCH) | SSB transmitted with 20ms periodicity  10% and 1% residual BLER after 4 retransmissions within MIB TTI of 80ms, UE is not assumed to know the SS/PBCH block index, wideband precoder, cycled for different transmissions |
| MSG1  (PRACH) | Format 0  10% and 1% missed detection at 0.1% false alarm probability, with maximum timing estimation error 50% of the normal CP length and 64 preambles per cell  Initial timing offset uniformly distributed in [0, 23 µs] corresponding to 6 km intersite distance (ISD). |
| 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  1% and 10% 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.  1% and 10% 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 39bits+24bits CRC  CORESET 48 PRBs, 2 symbols, non-interleaved mapping,  precoder cycling  1% and 10% error rate |
| DL data (PDSCH) | Link and rank adaption based on 20 slot wideband CSI feedback periodicity and HARQ with up to three retransmissions. 52 PRBs, 2 symbols with DMRS, PDSCH and DMRS mapped to 12 symbols (2 symbols reserved for PDCCH),  overhead due to CSI-RS and TRS with 20ms period  10% BLER |
| ACK/NACK  (PUCCH) | Format 1 with 1bit, 14 symbols long with 7 DMRS and frequency hopping Pr(DTX to ACK) <=1%, Pr(NACK to ACK) <=0.1%,  Pr(ACK error) <=1% or 10% |
| CSI feedback (PUSCH or PUCCH) | 5+2 bits for wideband CSI feedback for 2Tx  1 PRB, no HARQ ACK/NACKs  PUCCH format 3 with 4 DMRS and frequency hopping  PUSCH without multiplexing with data on PUSCH and no frequency hopping  1% and 10% error rate |
| UL data (PUSCH) | Link and bandwidth adaption based on DMRS and HARQ with up to three retransmissions. Up to 52 PRBs, 2 symbols with DMRS, PDSCH and DMRS mapped to 14 symbols and no UCI overhead included  10% BLER |

Table A4.1.4 Scenario for 4 GHz.

|  |  |  |
| --- | --- | --- |
| Parameters | 4 GHz: Rural | 4 GHz: Urban macro |
| Layout | Macro layer: Hex. Grid | Macro layer: Hex. Grid |
| Inter-BS distance | 1732m or 3 km | 500m or 700m |
| Carrier frequency | 4 GHz | |
| Aggregated system  bandwidth | 400mHz (DL+UL) | |
| Simulation bandwidth | 100MHz (TDD) | |
| Channel model | ITU RMa\_B | ITU UMa\_B |
| BS Tx power | 53dBm | 53dBm |
| UE Tx power | 23dBm | |
| BS antenna configurations & gain, including RF losses | AAS 128 antenna elements with (M,N,P,Mg,Ng) = (8,8,2,1,1) 32 TxRUs, (4x1 virtualization) 26dBi total max gain  Follow the modeling of ITU M.2412 | |
| Tilt: 6 deg | Tilt: 10 deg |
| BS antenna height | 35m | 25m |
| BS receiver noise figure | 5dB | |
| UE antenna configuration | 1T4R, [2T4R] | |
| UE antenna height | Follow the modeling of ITU M.2412 | |
| UE antenna gain | Isotropic, 0dBi | |
| UE receiver noise figure | 7dB | |
| Traffic model | Companies specify if full buffer or non full buffer is used when determining SINR statistics. | |
| Traffic load (Resource utilization) | See Table A4.1.5 | |
| UE distribution | 50% outdoor vehicles (120km/h) and 50% indoor (3km/h)  10 users per TRP for full buffer traffic  User distribution: Uniform | 20% Outdoor in cars: 30km/h,  80% Indoor in houses: 3km/h  Mix of O2I penetration loss models for higher carrier frequency  - Low loss model – 80%  - High-loss model – 20% |

Table A4.1.5. Desired and interfering signal assumptions for 4GHz.

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

Table A4.1.6 Link level assumptions and SNR requirements for 4GHz

|  |  |
| --- | --- |
| **Channel/Signal** | **Assumptions** |
| **Initial Access** | |
| SSB (P/S-SS and PBCH) | SSB 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  1% and 10% error rate |
| MSG1  (PRACH) | Format B4 (12 symbols) 10% and 1% missed detection at 0.1% false alarm probability, with maximum timing estimation error 50% of the normal CP length and 64 preambles per cell Initial timing offset uniformly distributed in [0, 1.9 µs] for 500 m ISD and [0, 6.7 µs] 1732 m ISD |
| 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  1% and 10% 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.  1% and 10% 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 44bits+24bits CRC  CORESET 273 PRBs, 2 symbols, non-interleaved mapping,  precoder cycling  1% and 10% error rate |
| DL data (PDSCH) | Link and rank adaption based on 20 slot wideband CSI feedback periodicity and HARQ with up to three retransmissions. 273 PRBs, 2 symbols with DMRS, PDSCH and DMRS mapped to 12 symbols (2 symbols 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 | 6 bits CSI part 1 (RI+CQI), 10 bits CSI part 2 (PMI1+PMI2) wideband reporting for type I feedback for an 8x2 port layout and up to rank four  1 PRB, no HARQ ACK/NACKs  PUCCH format 3 with 4 DMRS, with frequency hopping  PUSCH without multiplexing with data on PUSCH and no frequency hopping  1% and 10% error rate |
| UL data (PUSCH) | Link and bandwidth adaption based on DMRS and HARQ with up to three retransmissions. Up to 273 PRBs, 2 symbols with DMRS, PDSCH and DMRS mapped to 14 symbols and no UCI overhead included  10% error rate |

## A4.1 Proposal 2