**3GPP TSG RAN WG1 #106-e R1-21xxxxx**

**e-Meeting, August 16th – 27th, 2021**

**Agenda Item: 8.3.1.2**

**Source: Moderator (InterDigital, Inc.)**

**Title: [Draft] Feature lead summary #3 on CSI feedback enhancements for enhanced URLLC/IIoT**

**Document for: Discussion and Decision**

# Introduction

This contribution is a summary of contributions [2]-[24] submitted under AI 8.3.1.2 (CSI feedback enhancements) The AI is related to the following objective of the revised work item on Enhanced IIoT and URLLC support for NR [1]:

|  |
| --- |
| 1. Study, identify and specify if needed, required Physical Layer feedback enhancements for meeting URLLC requirements covering    * + UE feedback enhancements for HARQ-ACK [RAN1]      + CSI feedback enhancements to allow for more accurate MCS selection [RAN1]   Note: DMRS-based CSI feedback is not in scope of this WI |

In RAN1#102-bis-e and subsequent RAN1 meetings, RAN1 studied a set of CSI enhancement schemes in terms of technical benefits, specification and implementation impacts. The candidate enhancement schemes included new triggering methods for A-CSI and/or SRS, new reporting based on channel/interference measurement (Case 1), and new reporting based on other measurement (Case 2).

As of RAN1#105-e, RAN1 had not reached agreement on which scheme(s) are to be supported. In RAN#92-e, RAN provided guidance to focus on schemes proposed in RP-211297 [25]. More specifically, the schemes consist of the following:

|  |
| --- |
| RAN1 to further investigate the following for CSI enhancements for IIoT/URLLC:   * Increasing the number of bits used for the reported subband CQI (3-bits differential subband CQI or 4-bits CQI) * Reporting of delta-MCS:   + Report consists of delta-MCS for a TB received with MCS index IMCS:   delta-MCS is calculated from the difference between IMCS\_tgt and IMCS, where IMCS\_tgt is the largest MCS index such that the estimated BLER for a TB received with this MCS index would be smaller than or equal to a BLER target, and IMCS is the MCS index of the received TB. |

Here is the color code used in this summary:

* FL’s proposals
* Questions for the inputs from companies
* FL summary based on the companies’ input
* RAN1 agreements

# Collection of agreements/conclusion in RAN1 #106-e

**Agreement**

For subband CQI reporting with more than 2 bits per subband

* Support 4-bits CQI only

# Proposals for 1st GTW

**FL proposal 7.2-2:**

**Support one scheme of subband CQI reporting with more than 2 bits per subband**

* **FFS: Support 3-bits D-CQI or 4-bits CQI**

[For Delta-MCS]

Observations:

8 companies (Sony, Samsung, Ericsson, ZTE, QC, Quectel, CATT, OPPO) companies suggest to agree on supporting Delta-MCS now.

8 companies (Nokia, HW/HiSi, Apple, vivo, DoCoMo, LG, Mediatek, CMCC) would prefer to discuss and agree on design details further prior to deciding on whether to support Delta-MCS.

2 companies (Intel, Futurewei) do not agree on supporting Delta-MCS and do not want to discuss further.

Based on the above feedback, one possible way forward is to take a working assumption that Delta-MCS is supported so that we can make progress on the design.

**FL proposed working assumption 8.2-4**

**Support reporting of delta-MCS:**

* **Report consists of delta-MCS for a TB received with MCS index IMCS:**
  + **delta-MCS is calculated from the difference between IMCS\_tgt and IMCS, where IMCS\_tgt is the largest MCS index such that the estimated BLER for a TB received with this MCS index would be smaller than or equal to a BLER target, and IMCS is the MCS index of the received TB.**

**FL proposal 8.2-5**

* **Delta-MCS is reported in same resource as HARQ-ACK**
  + **FFS: Whether HARQ-ACK and Delta-MCS for a TB can be jointly encoded (multi-bit HARQ-ACK)**
  + **FFS: Supported HARQ-ACK codebook types**
  + **FFS: Required extension of UE processing timeline**
* **Support values {1e-1;1e-5} for the target BLER applicable to Delta-MCS calculation**
  + **FFS: additional values**
  + **FFS: Target BLER depends at least on MCS table used for the TB**
* **Support at least the case of 1 bit per TB (in addition to HARQ-ACK and if reported for the given TB)**
  + **FFS: More than 1 bit**
  + **FFS: Mapping to Delta-MCS values**
  + **FFS: Condition(s) for reporting Delta-MCS for a TB**

# Proposals for 2nd check point

TBD

# Proposals for 3rd check point

TBD

# Proposals for 4th check point

TBD

# Topic #1: Increasing number of bits for subband CQI report

In this section, we provide summary of contributions discussing candidate enhancement schemes involving increasing number of bits for subband CQI report.

## Evaluation results

Contributions from ZTE [6], Samsung [9], InterDigital [12], Futurewei [13], Mediatek [19], Intel [20] and ITRI [23] present evaluation results for subband CQI report with increased number of bits. The results are summarized in following Table:

|  |  |  |  |
| --- | --- | --- | --- |
| ZTE [6] | ~~3-bits D-CQI or~~ 4-bits~~?~~ | AR/VR  (40 UEs /cell) | 85.7% [86.7%] satisfied UEs  4.3 RU [4.3 RU] |
| Samsung [9] | 3-bits D-CQI | ??? | 0.2%, 1.9%, 1.0% gain for average/median/5 pctile throughput respectively. |
| Samsung [9] | 4-bits full CQI | ??? | 0.5%, 0.7%, 15.6% gain for average/median/5 pctile throughput respectively |
| InterDigital [12] | 3-bits D-CQI | AR/VR (20 UEs /cell) | 95.6% [93.6%] satisfied UEs  8.0 RU [7.7 RU] |
| InterDigital [12] | 4-bits full CQI | AR/VR (20 UEs /cell) | 95.6% [93.6%] satisfied UEs  8.0 RU [7.7 RU] |
| InterDigital [12] | 3-bits D-CQI | Factory (30 UEs /cell) | 94.6% [92.0%] satisfied UEs  6.7 RU [6.6 RU] |
| InterDigital [12] | 4-bits full CQI | Factory (30 UEs /cell) | 94.6% [92.0%] satisfied UEs  6.8 RU [6.6 RU] |
| Futurewei [13] | 4-bits full CQI | AR/VR  (20 UEs /cell) | 76.4% [48.2%] satisfied UEs  31% [71%] RU |
| Mediatek [19] | 3-bits D-CQI | Factory | 21.2% RU (25.1%) |
| Mediatek [19] | 4-bits full CQI | Factory | 21.2% RU (25.1%) |
| Intel [20] | 4-bits full CQI | Factory | 21% [25%] satisfied UEs |
| ITRI [23] | 3-bits D-CQI | Factory | 87.2% [63.3%] satisfied UEs  7.0% [6.3%] RU |
| ITRI [23] | 4-bits full CQI | Factory | 90.6% [63.3%] satisfied UEs  7.1% [6.3%] RU |

## Summary of issues for Topic #1

Most contributions discuss increasing number of bits for better accuracy of subband CQI.

**Issue #1-1: Support reporting with increased number of bits for subband CQI?**

Yes: Huawei [2], Vivo [3], Ericsson [4], Spreadtrum [5], Sony [7], Quectel [8], Samsung [9], Nokia [11], InterDigital [12], Futurewei [13], Qualcomm [16], LG [18], Mediatek [19], ITRI [23]

* Gains can be observed in evaluations [9][12][13][19][23], e.g. higher accuracy, higher % of satisfied UEs and reduced resource utilization.

Maybe: Lenovo [14], Intel [20], NTT DoCoMo [22]

* Little/no gain observed from evaluations from past [14][22] or current [20] meeting. Further evaluations are needed [14][20][22].
* Extended SINR range of legacy CQI table should also be supported [20]

No: CATT [10]

* Little/no gain observed from (past) evaluations

Within the contributions proposing increased number of bits for subband CQI, the following schemes are proposed:

**Issue #1-2: Proposed scheme for increased number of bits for subband CQI**

* **3-bits D-CQI format (with fixed values)**: Vivo [3], Spreadtrum [5], Sony [7], Quectel [8], Samsung [9], InterDigital [12], Qualcomm [16], Mediatek [19], ITRI [23]
  + Natural extension from 2-bits D-CQI [3][16]
  + Less overhead than 4-bits CQI
  + Most or all of the potential gain achieved with 3-bits [12][23]
* **4-bits CQI**: Huawei [2], Vivo [3], Spreadtrum [5], Sony [7], Quectel [8], Samsung [9], Nokia [11], Futurewei [13]
  + Provides full CQI report resolution [2]
  + Less specification effort than 3-bits D-CQI [2]
  + May not require WB-CQI as reference [2]
* **D-CQI with range and resolution indicator (RRI)**: Ericsson [4]
  + Provides reporting flexibility and granularity without excessive overhead [4]

Several contributions [2][3][7][8][9] propose that RRC can configure the subband granularity between legacy, 3-bits D-CQI or 4-bits CQI. This allows control of overhead by network.

Several contributions [8][11][18] propose enhancements that could limit the additional overhead compared to using a 3-bits D-CQI table or 4-bits CQI for all subbands, while still potentially bringing benefit from additional accuracy:

* Configure number of bits on subband basis [8]
  + Limit additional overhead when interference is expected to be low in certain subbands
* Support option where UE reports CQI from worst subbands only [11]
* Introduce indication of whether increased granularity is utilized in CSI part 1 [18]

**Observations on increasing number of bits for subband CQI report.**

Most of the evaluations available from the contributions submitted at this meeting show the potential performance gain of increasing the number of bits of subband CQI [9][12][13][19][23]. Two evaluations [6][20] do not find a gain. Because scheduler behaviour is not part of the assumptions, such discrepancies can be expected.

The contributions indicate that a strong majority of companies support introduction of subband CQI with increased number of bits. About half of companies prefer 3-bits D-CQI and half prefer 4-bits CQI. Several companies also propose that the network could decide to configure one or the other depending on whether UL overhead or accuracy is more important in a given scenario. In view of this, it is proposed to agree on the following:

**FL proposal 7.2-1:**

**Support at least the following schemes:**

* **3-bits differential subband CQI** 
  + **Adopt following mapping as baseline: {0,1,2,>=3,-1,-2,-3,<=-4}**
  + **FFS: Use of different mapping in place of the above**
* **4-bits subband CQI**
* **FFS: Additional schemes**

**RRC can configure use of wideband CQI, legacy 2-bits D-CQI or one of the above schemes for each CSI report configuration.**

## E-mail discussion (1st round) for Topic #1

**Question 1-1**: Please provide feedback if you would like to either (a) make correction in this moderator summary (Topic #1) or (b) add your company position

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Nokia/NSB | No |  |
| ZTE |  | In our simulation, 4-bits full CQI is adopted. Update accordingly. |
|  |  |  |

**Question 1-2**: Please indicate if FL proposal 7.2-1 is acceptable

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Nokia/NSB | Yes | “Adopt following mapping as baseline: {0,1,2,>=3,-1,-2,-3,<=-4}” is not fully clear to us. What is this trying to explain. |
| HW/HiSi | Yes | Similar to Nokia, we also think that {0,1,2,>=3,-1,-2,-3,<=-4}could be clarified and we are not sure if the 2 FFSs are needed. But we are ok to accept them for the sake of progress. |
| Intel | No | We think that it is premature to jump to this kind of details such as agreeing directly the offsets, etc.  We observe that simple increase of the signaling to 3 or 4 bits does not provide sufficient mechanisms for gNB to predict SINR distribution seen at the UE. Additional handling of very low or very high SINR is essential to give the accurate information to gNB. For that purpose, we suggest using resulting CQI ranges < 0 and > 15, as well as discuss how to interpret “out of range” CQI=0.  Having said that, the following modification would be fine with us:  **FL proposal 7.2-1:**  **Support at least the following schemes:**   * **3-bits differential subband CQI**    + **FFS differential sub-band CQI mapping to sub-band CQI offsets**   + **~~Adopt following mapping as baseline: {0,1,2,>=3,-1,-2,-3,<=-4}~~**   + **~~FFS: Use of different mapping in place of the above~~** * **4-bits subband CQI**   + **FFS: handling and interpretation of WB CQI for 4-bit SB CQI** * **FFS: handling and interpretation of “out of range” CQI including support of (WB CQI – SB CQI offset) < 0 and (WB CQI – SB CQI offset) > 15** * **FFS: Additional schemes**   **RRC can configure use of wideband CQI, legacy 2-bits D-CQI or one of the above schemes for each CSI report configuration.** |
| Sony | Yes | Firstly Proposal 7.1-1 does not exists. However, we are fine with Proposal 7.2-1 and to make it more palatable for others perhaps we can discuss the differential CQI mapping for 3 bits option after this agreement. That is on for the 3 bits bullet point, we propose the following:   * **3-bits differential subband CQI**    + **FFS: the different CQI mapping** |
| Futurewei | Yes | We are in general ok with the proposal. Fine with Sony’s revision. |
| Samsung | Yes | Fine with the update from Sony. |
| Apple |  | It is very important to clarify the condition of operating sub-band CQI with 4 bits or 3 bits. If frequency selective fading/interference is assumed, and they are assumed to be consistent/persistent across time (from feedback time to PDSCH reception), that assumption should be clarified. Note this is also related to the discussion on delta-MCS, the interference assumption should also be clarified. |
| Ericsson | No | * First, we do not see any performance justification to accept 4-bit subband CQI. Based on the simulation results submitted to this meeting, most companies’ observed that 4-bit subband CQI brings no or negligible performance improvement compared to 3-bit subband CQI, for example, Samsung [9], InterDigital [12], Mediatek [19], Intel [20]. Considering the substantially higher overhead, we definitely cannot accept 4-bit subband CQI. * Second, for 3-bit subband CQI, three companies (ZTE [6], Samsung [9], InterDigital [12],) shows negligible/marginal gain compared to 2-bit baseline, while two companies (Mediatek [19], ITRI [23]) shows noticeable gain compared to 2-bit baseline. In our view, this is not convincing to introduce 3-bit subband CQI, since it increases the subband CQI reporting overhead by 50%.   In summary, we don’t think RAN1 should rush to adopt the method of improved subband CQI granularity. RAN1 should investigate further the cost and benefit before adoption. Even if the method is justified, schemes that improves the subband CQI range and granularity, but minimizes overhead, should be preferred, for example, Alternative 1 in Ericsson [4]. |
| ZTE | No | We have a question on the FFS part. Does it mean we need to further study additional schemes besides the 3/4 bits CQI? According to the previous agreements, we have only 3/4 bits CQI on the table. It is better not to introduce more schemes at this stage. |

|  |  |  |
| --- | --- | --- |
| QC | No | In general, we have similar view as Ericsson on increase the subband CQI granularity. But we could make a compromise to accept one scheme between the 3-bits differential subband CQI and 4-bits suband CQI. Between the two, we can accept 3-bits differential subband CQI, because 1) smaller overhead; 2) naturally extension of legacy 2 bits differential subband CQI; 3) no significant performance difference between the two schemes. We don’t see the need to adopt both schemes and force UE to implement two different schemes for a same functionality.  Second comment is similar to what Sony and other companies already mentioned. It is premature to settle down the offset quatization, without some discussion within the group. |
| Quectel | Yes | We are in general ok with the proposal. Fine with Sony’s updates. We don’t think the FFS for additional schemes is needed. According to the guidance from RNP, we don’t think it is good to reopen the discussions for other schemes. |
| vivo | Yes | We are supportive of FL’s proposal but without the FFS. We are not sure whether these FFSs are needed and it should be clarified what is the intentioan for the FFSs. We think 3-bits differential subband CQI or 4-bits CQI should be the case according to RANp suggestion. |
| DOCOMO | Yes | We share similar views as Ericsson and Qualcomm in general but can accept the proposal with modification from Sony. In order to reduce the overhead, the proposal in Ericsson could be considered for the 3bits differential subban CQI. |
| LG | Yes | We also share similar view to Sony. At the current stage, it is not necessary to define offset in the table.  On the FFS part ; additional scheme, the overhead should be minimized for the performance but it could be just how to indicate/utilize 2/3/4bit CQI reporting adaptively, rather than new additional schemes. That should be clarified. |
| CATT | No | Similar as Qualcomm, we can compromise to support one scheme between 3-bits differential subband CQI and 4-bits subband CQI. In addition, we also agree to keep the mapping open for now. |
| OPPO | No | We do not think it is necessary to support both solutions. If RAN1 can agree to choose just one, we can accept either way. |
| MediaTek | Yes | As our simulation results show, 3-bit D-CQI is sufficient to report accurate CQI. 4-bit SB-CQI requires more overhead without providing meaningful gain. Thus, our preference to support 3-bit D-CQI only. However, given that 4-bit SB-CQI requires only very basic change, we don’t object to having it in addition to 3-bit D-CQI. |
| CMCC | Yes | We are fine with SONY’s version.  It is better if we can have just one solution between 3bits/4bits however if it is hard to make a decision barely from simulation, having a flexible RRC configuration to choose, is a good way. Because we can always verify and compare them in live network. |
| Spreadtrum | Partially Yes | We can accept one of 3 bits or 4 bits, but not all of them.  **Support at least one of the following schemes:** |
|  |  | @Sony: Fixed the proposal number in the question, thanks.  @All: OK to discuss the mapping later and remove corresponding bullet  @Intel: At least InterDigital results were based on estimating distribution tail based on CQI reports received at gNB, and these results showed some improvement when going from 2-bits to 3-bits D-CQI. Regarding your proposal on mapping CQI to extended SINR range, at this late stage of the WI it does not seem possible to open this for further study.  @Apple: The fading/interference characteristics should correspond to what we agreed at the beginning of the WI (AR/VR, Factory). Based on InterDigital results there seems to be a benefit from higher granularity even with bursty fading/interference because the gNB obtains better estimate of the CQI distribution when the CQI reports from UE have better accuracy.  @Ericsson: At least the 3-bits scheme seems to provide reasonable gain for the UL overhead cost (going from 92% to 95% satisfied UEs is not negligible). Regarding new proposal on RRI, it seems difficult to initiate study on it at this late stage of the WI.  @QC, CATT, OPPO, Spreadtrum: Updated proposal will be to support only one scheme.  @LG: For the table selection/configuration, suggest to discuss this as next level of detail.  @ZTE, Quectel, vivo: Updated proposal will not include this FFS. |

In view of the feedback, FL proposal is updated as follows:

**FL proposal 7.2-2:**

**Support one scheme of subband CQI reporting with more than 2 bits per subband**

* **FFS: Support 3-bits D-CQI or 4-bits CQI**

## E-mail discussion (2nd round) for Topic #1

Following agreement at the GTW, one issue is the configurability aspect. Several contributions submitted at RAN1#106-e proposed that RRC configures between legacy 2-bits D-CQI, 3-bits D-CQI and 4-bits CQI. Since the agreement taken at GTW excludes 3-bits D-CQI, the configurability should now be between legacy 2-bits D-CQI and 4-bits CQI for subband CQI. This leads to the following proposal:

**FL proposal 7.2-3:**

**RRC can configure use of wideband CQI, legacy 2-bits D-CQI or 4-bits CQI for each CSI report configuration.**

**Question 1-3**: Please indicate if FL proposal 7.2-3 is acceptable.

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| QC | Yes |  |
| vivo | Yes |  |
| Intel | Yes |  |
| CATT | Yes |  |
| ZTE | Yes |  |
| Futurewei | Yes |  |
| Nokia | Ok | We agreed to 4-bit sub-band CQI reporting, and the proposal should be the following. Anyways, we do not think this needs a new agreement.  **RRC can configure 4-bit sub-band CQI reporting (using a similar method as legacy 2-bit sub-band CSI reporting) within a CSI report configuration.** |
| Sony | Yes |  |
| HW/HiSi | Yes |  |
| LG | Yes |  |
| Lenovo, Motorola Mobility | ok |  |
| Spreadtrum | Yes |  |
| DOCOMO | Yes |  |
| Quectel | Yes |  |

Other aspects

As indicated in summary, several contributions [8][11][18] propose (or mention) possible optimizations that could limit the additional overhead with 4-bits CQI

* Configure 4-bits subband CQI on subband basis [8]
* Support option where UE reports CQI from worst subbands only [11]
* Introduce indication of whether increased granularity is utilized in CSI part 1 [18]

**Question 1-4**: Please indicate whether one or more of the above enhancements can be considered for further discussion and possible support.

|  |  |
| --- | --- |
| Company | Comments |
| QC | In general, the benefit of mixing 4-bits and 2-bit subband CQI feedback in one report is questionable to us. We understand the motivation is to reduce CQI overhead. But the question is who decides a particular subband should report 4 bits or 2 bits CQI. gNB cannot decide this because gNB does not know the channel. UE could decide this. But the problem is that how does gNB decode and interpret the CQI report, given the variable CQI size per subband. 2-Step approach as in [18] can partially solve the issue but the 2-step indicator itself is addiontal overhead. Adding overhead for the purpose of reducing overhead seems a little strange. |
| Vivo | We don’t see the need to support these additional optimizations for 4-bits subband CQI. |
| Intel | Configuration-based sub-bands with 4-bit CQI is not going to work, as pointed out by QC.  UE reporting of CQI from worst sub-bands only goes beyond the agreements, which precluded worst SB filtering.  Overall, our understanding that agreeing on 4-bit CQI we accepted the 4-bit OH per sub-band. The more important questions would be how to handle WB CQI, ‘out of range’ CQI, very high SINR, very low SINR. |
| CATT | WE don’t see the need for any of the optimizations. |
| ZTE | We share the same view with vivo and CATT that there is need to further optimize 4-bits suband CQI. |
| Futurewei | At this late stage, we don’t see the need of further optimization on the 4-bit subband CQI. If overhead is a concern, RRC can be used to configure the use of legacy 2-bit D-CQI as described in FL proposal 7.2-3. |
| Nokia | Open for discussing reporting worse subband only report if other companies understand the value of it. |
| Sony | We do not see the need for further optimisation. |
| HW/HiSi | It is also our view that there is no need for further optimization. |
| LG | We are open to discuss for further optimization with least specification impact.  The problem of 4bit CQI via RRC configuration is that UE always use 4bit even if chanel is stable. Two step approach in [18] allows for UE to determine which CQI bit size is used per sub-band, so overall overhead can be reduced dramatically. Expected specification impact is only adding one indicator to part 1 CSI. |
| Lenovo, Motorola Mobility | In our vew, it is better to conclude the basic design for the CSI A.I., and then revisit if any optimization needed to be discussed. |
| Spreadtrum | Three optimizations are not needed. |
| DOCOMO | We don’t see the need for futher optimization at this late stage. |
| Quectel | We are open for further optimizations for overhead reduction. |

It would be good to understand what other aspects should be further decided to complete the work related to 4-bits subband CQI. For example, one aspect not discussed in contributions is whether 4-bits subband reporting can be applicable to any CQI Table or only to certain CQI Table(s) (e.g. CQI Table 3). There may be further aspects to decide on as well.

**Question 1-5**: Please indicate which CQI Table(s) subband reporting with 4-bits CQI can be applicable to.

|  |  |
| --- | --- |
| Company | Applicable CQI Tables |
| vivo | Table 1/2/3 |
| Intel | Any table, there is no motivation to limit applicability |
| CATT | All the CQI tables. |
| ZTE | All the current CQI tables. |
| Futurewei | It should be applicable to any CQI Table. |
| Nokia | All |
| Sony | All the CQI tables. |
| HW/HiSi | All current CQI tables. |
| LG | All three table can be considered. |
| Lenovo, Motorola Mobility | All tables |
| Spreadtrum | All tables. |
| DOCOMO | All |
| Quectel | All |

**Question 1-6**: Please indicate what should be further decided to complete the work on 4-bits subband CQI.

|  |  |
| --- | --- |
| Company | Comments |
| Intel | As we analyzed in our tdoc, there are still issues with 4-bit CQI reporting.  Previously companies analyzed so called statistical CSI or worst interference CSI, etc. approaches. Those were not agreed assuming the increased SB signaling can provide similar information to gNB.  Extension of SB CQI to 4-bit does not provide full information to gNB about SINR distribution at the UE in the very low or very high SINR region. For example, it is highly uncertain what to assume at gNB if ‘out of range’ CQI is reported. In IIOT scenarios we observe that ‘out of range’ CQI is not a rare state.  In summary, we propose that RAN1 looks into the following associated issues:   * WB CQI interpretation and handling when 4-bit SB CQI is reported * ‘out of range’ CQI enhancements   Extension of SE/SINR range of a CQI table by an enhanced WB + SB CQI reporting |
| Nokia | Nothing that we are aware of. |

Moderator observations:

* FL proposal 7.2-3 seems agreeable to all. This proposal will be identified for email approval.
* Majority of companies do not see a need for further optimizations to limit additional overhead.
* All companies think that the functionality should be applicable to all CQI tables
* One company (Intel) thinks RAN1 should study how to more precisely map out-of-range value and handling of WB CQI.

## E-mail discussion (3rd round) for Topic #1

One issue related to Intel’s suggestion is whether wideband CQI is still reported in a report containing 4-bits subband CQI. It could be assumed that such reporting is unnecessary as the gNB can infer the wideband CQI from the individual subband CQI values. However, it would be good to get confirmation from companies on this.

**Question 1-7**: Please indicate whether wideband CQI is still reported in a report containing 4-bits subband CQI.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung | Yes.  No other change to the CQI report structure is needed. The WB-CQI functionality does not change due to the number of bits for SB-CQI. |
|  |  |

**Question 1-8**: Please indicate if RAN1 should study/support enhanced mapping of out-of-range CQI value.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung | No. |
| QC | No. The motivation of enhancing the mapping of out-of-range CQI seems not clear to us. If Intel can illustrate more what is the issue, we can be open to discuss further. |

# Topic #2: Delta-MCS

In this section, we provide summary of contributions discussing Delta-MCS reporting.

## Evaluation results

Contributions from ZTE [6], InterDigital [12], Futurewei [13], Qualcomm [16] and Intel [20] present evaluation results for Delta-MCS. The results are summarized in following Table:

|  |  |  |  |
| --- | --- | --- | --- |
| ZTE [6] | Delta-MCS | AR/VR | 94.8% satisfied UEs [86.7%]  8.1% RU [4.3%] |
| InterDigital [12] | Delta-MCS | Factory | 100% satisfied UEs [99%]  5.0 RU [4.8] |
| InterDigital [25] | Delta-MCS | Factory | 72.4% satisfied UEs [54.3%]  4.1 RU [4.1]  (bias reset every 300 ms) |
| Futurewei [13] | Delta-MCS | AR/VR | 25.3% satisfied UEs [48.2%]  93% RU [71%] |
| Qualcomm [16] | Delta-MCS | AR/VR (mixed traffic, 20 URLLC UEs) | 100% satisfied UEs [100%]  930 RBs for 2nd Tx [1445] |
| Qualcomm [16] | Delta-MCS | AR/VR (mixed traffic, 100 URLLC Ues) | 100% satisfied UEs [100%]  5878 RBs for 2nd Tx [7545] |
| Intel [20] | Delta-MCS | Factory | 20% [25%] satisfied UEs |

## Summary of issues for Topic #2

The most important issue is obviously whether Delta-MCS should be supported. Views from contributions are summarized as follows.

**Issue #2-1**: Support Delta-MCS reporting?

Yes: (Ericsson [4]), Spreadtrum [5], ZTE [6], Sony [7], Quectel [8], Samsung [9], CATT [10], Nokia [11], InterDigital [12], Lenovo [14], Oppo [15], Qualcomm [16], CMCC [17], LG [18], NTT DoCoMo [22]

* Direct way to feedback decoding margin [5]
* Can provide exact channel state more frequently and timely, efficient scheduling, Robust to channel variation and bursty interference [6][16]
* Enhance OLLA operation [10][22]
* Legacy OLLA not feasible solution for URLLC [11][15]. Normal link adaptation cannot track fading/interference fast enough [16]. Unpractical to set step size of NACK 9999 times of ACK otherwise MCS is always 0 [16].
* CQI not available in time for retransmission, information from PDSCH decoding does not require extra computation [15]
* Better capability of target BLER tracking than baseline [15]
* Avoids excessive SNR backoff for retransmission [16]

Maybe: Huawei [2]

* Only if A-CSI on PUCCH is supported

No: Vivo [3], Futurewei [13], Mediatek [19], Intel [20]

* Only useful if retransmission is in same resource (scheduler flexibility), Delta-MCS does not provide information on future interference [3][13]
* BLER target applied at gNB may be different from BLER target assumed by UE [3]
* No evident performance gains [3][20]
* Less efficient than periodic/aperiodic CSI report [3], no need for periodic data traffic [19]
* Non-trivial spec impact (reporting resource and channel, how to trigger, impact on HARQ codebook, whether to report for every PDSCH, handling for multiple PDSCHs, testability) [3][20]
* Similar to A-CSI on PUCCH if for retransmission, wasted power consumption [19]
* Large overhead/reliability loss to add for every ACK position in codebook, impacts processing timeline, possible ambiguity if report is conditional [19]

Contributions also provide views and alternatives on the following issues related to support of Delta-MCS:

**Issue #2-2:** Resource for transmission of the Delta-MCS report

* **In same resource as HARQ-ACK (extended HARQ-ACK codebook or appended to HARQ-ACK)**
  + Yes: Ericsson [4] (not Type-3), Spreadtrum [5], ZTE [6], Quectel [8], Samsung [9], Nokia [11], InterDigital [12], Lenovo [14], Oppo [15], Qualcomm [16], LG [18] (not for all HARQ-ACK), Apple [21], NTT DoCoMo [22] (not Type-1)
    - No need for extra timing or resource indication [4]
    - Ensures timely reporting for HARQ Retx [6][11][15]
    - HARQ-ACK and Delta-MCS can be jointly encoded [4][9]
* **In PUCCH resource separate from HARQ-ACK**:
  + Yes: Huawei [2]?, LG [18], (NTT DoCoMo [22]), (Ericsson [4])
    - Can use A-CSI on PUCCH [2][22]
    - On next available periodic PUCCH [18]
  + No: Quectel [8], Samsung [9]
    - High specification impact, e.g. determining PUCCH resource, overlapping, coding UCI multiplexing, dropping [8][9] need to identify reference PDSCH [14][15]
    - Smaller encoding gain compared to joint coding with HARQ-ACK [9]
    - May not be feasible for TDD [9]
    - (Would increase DCI overhead) [10]
    - Increased uplink overhead due to transmission in different resource[15]
* **In MAC CE**: InterDigital [12]
  + Delta-MCS for OLLA does not require urgent transmission, can use averaging [12]

**Issue #2-3**: What target BLER is assumed by UE for calculating Delta-MCS?

* Single fixed value [21]
  + Ease UE implementation burden [21]
* Support only two values {1e-1;1e-5} [15]
  + Supporting arbitrary target BLER values increases UE implementation complexity [15]
* More than two values possible [4]
  + gNB may want to target values in between, difficult to infer from different target BLER [4]

**Issue #2-4**: How to indicate the target BLER value to UE?

* Semi-static configuration [4][15][22]
  + Per SPS config [7]([11])
  + Per serving cell [15]
* Tied to MCS Table used for the TB [9]([11])[12][14]
  + Since low-SE MCS Table target low BLER
* Indication in DCI (existing or new field) [7]([11])[15]
  + MCS-RNTI for DG [7]([11])
  + Priority index [15]
  + NDI toggling [15]
* Depends on ACK or NACK status of TB [15]

Possible conditions or triggers for reporting Delta-MCS are proposed or mentioned in contributions. Some contributions also suggest to consider reporting of Delta-MCS that is a function of multiple received TBs.

**Issue #2-5**: Possible conditions for reporting delta-MCS for a received TBs

* For single codeword case only [4]
* SPS PDSCH only [4]
* Dynamically indicated [5]([10])
* Trigger by (last) DL DCI, or enabled by RRC/MAC CE [6]([10])
* For certain HARQ processes ([8],[10])
* For certain CCs ([21])
* Time window, e.g. within HARQ feedback window [10]
* For certain PHY priority ([11])[12]
* Configured TBS/MCS threshold ([11])
* If the number of PDSCH Res is large enough [14]
* For certain counter DAI values only [15]

**Issue #2-6**: Whether to support single Delta-MCS that is function of Delta-MCSs of multiple received TBs

* Study multiple PDSCH to one delta-MCS [5][7][18]
  + Reduces accuracy: Lenovo [14]
* Reporting may be per CC/serving cell [10][15]
* Grouping by subband [15]

Contributions also discuss the number of bits of a Delta-MCS for a TB and mapping to Delta-MCS values.

**Issue #2-7**: Number of bits for Delta-MCS of a TB (excluding HARQ-ACK)

* 1 bit: Ericsson [4], Nokia [11], InterDigital [12], Qualcomm [16]
  + May consist of 2-bits joint HARQ-ACK/Delta-MCS [4]
* 2 bits: Ericsson [4]
* 2 bits or more: CATT [10]
* Configurable (e.g. 1, 2 or 3 bits): ZTE [6], Samsung [9]

For the mapping to Delta-MCS codepoint to Delta-MCS values, the following aspects are addressed:

**Issue #2-8**: Mapping Delta-MCS values to Delta-MCS codepoints

* RRC configures granularity: Samsung [9]
* May depend on MCS reference: Oppo [15]
* Both positive and negative delta-MCS should be mapped in case of ACK [4]
* Whether an MCS index offset should be configurable?
  + Yes: Huawei [2]
  + No: Samsung [9], InterDigital [12]

**Issue #2-9:** Delta-MCS calculation with PDSCH that carries retransmitted TB

* Whether calculation should take into account soft-combining gain [4][21]
* Whether PDSCH of retransmission or initial transmission is used as reference resource [4]
* Whether MCS used as reference is MCS of retransmission or effective MCS from combining [4]
* Which MCS table to use as reference [4]
* Calculate MCS index closest to corresponding code rate in case MCS index is 29, 30 or 31 [15]
* Calculate Delt-MCS considering TCI state, # of spatial layers, PRB bundling, etc. [21]

**Other issues / proposals**

* TB size assumption for delta-MCS calculation is same size as received TB [6][9][21]
* Frequence allocation assumption is same as current PDSCH [21]
* From testing perspective, UE is not required to meet the BLER target if a set of suitable conditions are not met [21]: same transmission parameters for the retransmission, CBGTI consistent with UE feedback, etc.
* Consider additional UE processing time (d3) for lower capability UE when Delta-MCS is calculated [4]
* Do no support/consider multi-TRP operation [4]
* Use Delta-CQI with CQI from latest CSI-RS as reference [2]. *Moderator’s note: this seems precluded by RAN guidance.*
* No need to define estimated BLER of a TB in terms of probability estimate of a code block within a TB [9]
* Single Delta-MCS is reported for whole TB even in case of CBG [4]
* Need to address priority between Delta-MCS and other UCI [18]

**Observations on Delta-MCS**

Observations on system-level evaluations

For the decision on whether to support Delta-MCS or not, RAN1 could not make agreement at the previous meeting because of concerns that it would not bring sufficient benefits. At this meeting, 5 companies provided system-level evaluation results in this meeting. 3 companies (ZTE, InterDigital, Qualcomm) identify a performance gain while 2 companies (Futurewei, Intel) obtain a performance loss. Although multiple factors may explain the discrepancies (e.g. differences in scenario/traffic/CSI reporting configuration assumptions), it is likely that a major reason is that the scheduler is modeled differently between the different companies, including OLLA operation and related parameters.

Another question is whether the simulation methodology is entirely appropriate to assess the potential benefits of Delta-MCS. For example, one potential benefit for Delta-MCS is to improve convergence time of OLLA when BLER target is very low. Fast convergence time is important to adapt to variations in channel and/or interference statistics (e.g. average and standard deviation) that may change over time due to mobility and traffic variations over larger time scales. Current simulation assumptions model very well short-term channel and interference variations but perhaps not as well the longer-term variations due to these effects that occur in real-life scenarios. On the other hand, when it comes to the potential benefit of providing guidance on appropriate MCS for retransmission, the simulation methodology seems adequate.

Overall, because of the differing evaluation results and possible inherent limitations of current system-level simulation methodology for capturing all potential benefits of this functionality, it seems difficult to make decision that would be based only on the available evaluation results. Other aspects that could be considered include for example analysis of convergence performance such as illustrated in [15] or [25].

Design aspects

If RAN1 agrees to support Delta-MCS reporting defined as per RAN guidance, a number of issues need to be discussed. The definition used in RAN guidance is as follows:

*Report consists of delta-MCS for a TB received with MCS index IMCS: delta-MCS is calculated from the difference between IMCS\_tgt and IMCS, where IMCS\_tgt is the largest MCS index such that the estimated BLER for a TB received with this MCS index would be smaller than or equal to a BLER target, and IMCS is the MCS index of the received TB.*

From this definition one identifies the following issues which are discussed in contributions.

* (2.2) Resource for transmission of the delta-MCS report
* (2.3, 2.4) Applicable BLER target
* (2.5, 2.6) Reporting of Delta-MCS as a function of received TBs
* (2.7, 2.8) Mapping between delta-MCS value and difference between *IMCS\_tgt and IMCS*
* (2.9) Delta-MCS calculation with PDSCH that carries retransmitted TB

On the resource (2.2), majority view is that Delta-MCS should be transmitted in same resource as HARQ-ACK as it ensures timely reporting and avoids the problem of provisioning an additional resource.

**FL proposal 8.2-1:**

**Delta-MCS (if supported) is reported in same resource as HARQ-ACK**

* **FFS: Whether HARQ-ACK and Delta-MCS for a TB can be jointly encoded (multi-bit HARQ-ACK)**

On the BLER target (2.3, 2.4), some companies have concern that requiring the UE to perform estimation for arbitrary values may be challenging for implementation, while other companies have concern that the information provided to the network may be difficult to use if the network wants to operate at a different target BLER than used by the UE. As a starting point, moderator suggestion is to agree on supporting at least two values. For the selection of value applicable to a TB, 3 companies proposed to make association with MCS table, in line with the motivation of introducing additional MCS table for URLLC in R15.

**FL proposal 8.2-2**

**For the target BLER applicable to Delta-MCS calculation (if supported)**

* **Support values {1e-1;1e-5}**
  + **FFS: additional values**
* **Target BLER depends at least on MCS table used for the TB**
  + **FFS: whether value for each MCS table is fixed or configured by RRC**

On the number of bits for Delta-MCS (2.7), 4 companies think that the case of 1 bit should be supported and 2 companies would support configurable number of bits for Delta-MCS that would include 1 bit as an option. From this the following is proposed:

**FL proposal 8.2-3**

**For Delta-MCS report (if supported), at least the case of 1 bit per TB (in addition to HARQ-ACK) is supported.**

* **FFS: More than 1 bit**

## E-mail discussion (1st round) for Topic #2

**Question 2-1**: Please provide feedback if you would like to either (a) make correction in this moderator summary for your company position (Topic #2) or (b) add your company position

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Nokia | Yes |  |
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|  |  |  |

**Question 2-2**: Please indicate any comment or clarification question on evaluation results from another company.

|  |  |
| --- | --- |
| Company | Comments/questions |
| QC | To Futurewei and Intel: delta-MCS feedback is additional/extra CSI feedback on top of legacy CSI feedback basedline (based on CSI-RS), how could additional CSI degrade system performance comparing to baseline? The observation of performance loss with delta-MCS must be due to a wrong/inpropriate gNB scheduling algorithm applied to delta-MCS feedback. A very simple logic: if gNB simply ignores the additional delta-MCS feedback, the system should achieve exact the same performance as the baseline which is without delta-MCS. We suggest Futurewei and Intel check the scheduler algorithm to see if there is bug in the algorithm.  To intel: To following result (copied from 210-7584) is very confusing. First of all, based on the contribution, the x-axis PER is the one time transmission BLER without retransmission. Now, if we set BLER target to 10^-5, from the result, only 25% UE can meet this BLER (regardless which of the 3 scheme is applied). This means the system does not work at all! Any conclusion drawn at 10^-5 BLER operating region seems meaningless. On the other hand, if we set the BLER target lower, i.e., 10^-4, the result show delta-MCS has better performance (90% UE satisfy) than baseline (80% UE satisfy). Then the result indeed shows delta-MCS scheme has gain over the baseline. We don’t know why Intel observed performance loss with delta-MCS scheme from this result. |
| Futurewei | Response to Qualcomm: Additional/extra feedback does not necessarily lead to better performance. If the additional feedback is not helpful or even misleading, e.g., could not appropriately indicate the CSI status of future PDSCH reception time due to significant variation of the interference, using this additional feedback could actually lead to worse performance. In this case, it would be better not send this additional feedback at all.  We notice that in Qualcomm’s system level simulation, the performance in terms of percentage of satisfied Ues are the same with and without delta-MCS. The only gain shown for delta-MCS is the resource savings for retransmission. Considering that in URLLC, the chance of retransmission is low, what is the overall resource savings taking into account both the initial transmission and retransmission? |
| QC | Response to Futurewei:  Regarding Futurewei’s (& Intel’s) simulation results, the problem is obvious. Like I mentioned already, the most naïve way for a scheduler to use the additional/extra delta-MCS feedback information is not using it. Then you should observe the same performance between baseline and baseline+delta-MCS. The only explanation of the performance loss with delta-MCS in Futurewei’s results is that the scheduler does not use delta-MCS feedback properly. I sincerely suggest Futurewei to check the gNB scheduler algirothm in your simulator.  Regarding QC simulation results, we simulated a relatively lighly loaded system with up to 100 URLLC Ues, due to extremely long simulation time. To get 10^-5 BLER, you will need to run at least 10^7~10^8 slots. It is impractical to run the simulator with many Ues. In a lightely loaded system, yes, the UE satisfying ratio are 100% between baseline and baseline+delta-MCS, because gNB always has enough resources to schedule retransmission after get a NACK for a TB. But the baseline use 25% more resources for retransmission comparing to with delta-MCS feedback. When the system loads more and more Ues, gNB will run into a situation of RB shortage for retransmissions for some Ues and those UE will fail URLLC requirements due to failed TBs cannot be retransmitted within latency requirement. That is why we think resource utilization for retransmission is an important metric for URLLC Ues, while the summation of resource utilization of ReTx and initial Tx is less important. And we show that delta-MCS has gain in terms of retransmission resource utilization. |
| MediaTek | We have the following questions on the results provided by ZTE. It will be appreciated if ZTE can provide some information on them.   * In R1-2104327, you compared the WB-CQI (Case 0-1) with SB-CQI-R16 (Case 0-2) reporting, and the results have shown that there is significant performance gain (lower BLER and RU, more accurate MCS selection, and higher number of satisfied UEs) by reporting the SB-CQIs. So, this clearly indicates that the **gNB requires the SB-CQIs to make better scheduling decision by selecting sub-bands with good CQIs**.   However, in R1-2106735, you compared SB-CQI-R16 (which quantized SB-CQI) scheme with full SB-CQI (4-bit) scheme, and for some reason the performance degraded when the more accurate SB-CQIs reported. If the scheduler is actually benefiting from knowing the channel information on the sub-bands (as shown R1-2104327), how come it becomes harmful to the scheduler to know more accurate channel information of the sub-bands (what reported in R1-2106735)!  So, could please provide information on the following: Why the performance improves when SB-CQIs (based on R16) were reported compared to WB-CQI, while it degrades when more accurate SB-CQIs (4-bit) are reported?   * Could you please provide information on why there is significant difference between the same baseline results reported in R1-2104327 and R1-2106735 (please see below). The simulation assumptions in both Tdocs are identical.  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | Cases | Percentage  (%) | BLER of 1st | RU(%) | Aggressive MCS ratio (%) | | R1-2104327 | Case 0-2 | 49.52 | 0.1692 | 1.88 | 29.73 | | R1-2106735 | Baseline | 86.67% | 0.1588 | 4.30 | 0.1638 | |
| Futurewei3 | Response to Qualcomm: The algorithm on how the gNB utilizes the delta-MCS is described in our contribution R1-210708. As we mentioned previously, delta-MCS may not appropriately indicate the CSI status of future PDSCH reception time due to significant variation of the interference, therefore utilizing delta-MCS could lead to performance loss. Please note that some results from last meeting (please see R1-2106177) also showed that utilizing delta-MCS could lead to performance loss. Of course if delta-MCS is not utilized, then there will be no performance loss. But then what is the purpose of reporting delta-MCS if it is not used?  Regarding Qualcomm’s results, it will be interesting to see the RU level taking into account both the original transmission and retransmission if Qualcomm already collected those data. In the end, it is the percentage of satisfied Ues that really matters, and how much the savings in RU for retransmission can translate into a change in percentage of satisfied Ues remains to be answered with simulation results, instead of speculation. |
| ZTE | Response to MediaTek:  Thanks for the question.  For the Case 0-2, the sub-band CQI is reported. So the network can select the best sub-band and perform scheduling based on the accurate sub-band CQI. However, for the Case 0-1, only a WB CQI is reported. When scheduling, it may select a bad sub-band, where the actual CQI is worse than the WB CQI. It leads to a aggressive scheduling since only the WB CQI can be used. So the aggressive MCS ratio for the Case 0-1 is much higher than that for Case 0-2. And the BLER of the first transmission is also higher. So the performance of WB CQI is worse than sub-band.  For the full SB CQI, the actual CQI is reported for the sub-band. For the legacy SB CQI report, the reported CQI may be less than the actual CQI for the best sub-band if the difference between the sub-band CQI and WB CQI is larger than 1. The network always select the best sub-band for scheduling. So the legacy SB CQI can get a more conservative scheduling than the full SB CQI. We can see, for the legacy SB CQI, the BLER of the first transmission and the aggressive MCS ratio are both lower a bit than the full SB CQI. That’s why legacy has a bit better performance than the full SB CQI.  Regarding the difference between the simulation results in our contributions, the reason is the initial values of the backoff for the OLLA are different. In the last contribution, we use a less value so that the scheduling is more conservative. This can be observed by the aggressive ratio. Of course, more resources are required. |

**Question 2-3**: Please indicate if you agree with the observations on Delta-MCS evaluations in previous section, and if you have any other observations.

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| --- | --- | --- |
| Company | Yes/No | Comments |
| Intel |  | We observe that as in prior meetings, this meeting the results provided by companies are **far from justifying the huge spec changes**.   * 2 sources provide gains in the target metric (% satisfied Ues) * 2 sources provide losses in the target metric (% satisfied Ues) * 1source provides no gain in the target metric, but provides gains in RU of 2nd TX, which translates to ~2 % total RU gain assuming even relatively high initial TX target BLER of 1 %   Overall, it is highly uncertain in which conditions which gains (or losses) can be achieved. |

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| QC | No | As we replied for question 2-2, delta-MCS should be able to perform at least as good as baseline, because delta-MCS is additional feedback on top of baseline. |

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**Question 2-4**: Based on the observations and considering that large majority of companies support it, can we agree now on supporting Delta-MCS? If not, what should be the next step (e.g. additional evaluation or no support for R17).

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| --- | --- | --- |
| Company | Yes/No | Comments |
| Nokia |  | We shall discuss the details releated to delta-MCS prior concluding that it can be supported. Conditionally agreeing (‘if supported”) on details will allow companies to simulate delta-MCS with a common framework and see the gains/issues of the scheme. |
| HW/HiSi | No | If delta-MCS should be supported, the design principles associated with it should be agreed firstly.  If this scheme is introduced, it is critical that it can be employed in a meaningful way. Therefore, if delta-MCS is introduced, it should have a low UL overhead, it should not impact the performance of HARQ-ACK and it should not restrict the scheduling flexibility. We are reluctant to support delta-MCS without having agreed on its design details firstly.  To ensure a low UL overhead and at the same time to allow the gNB to schedule a TB with a flexible BLER target, either the TB’s BLER target be known at the UE.  Additionally, the HARQ-ACK performance should not be degraded. To avoid this, the delta-MCS report could be sent on a separate PUCCH. Or, if the HARQ-A/N and delta-MCS are sent on the same PUCCH, the gNB should have the possibility to choose (i.e. to trigger), when it wants to receive a delta-MCS report. Otherwise, there could come situations where the increased payload results into a loss of reliability of the HARQ.ACK. |
| Intel | No | We suggest to select only one of Case-1 or Case-2 schemes to move forward. Among the two, Case-1 (enh SB-CQI) has no concerns and has much clearer spec impact, while Case-2 (delta-MCS) has quite high spec effort –to- system gain ratio, which should be avoided. |
| Sony | Yes | On HW’s point about flexible BLER target, the UE does not need to know the BLER target of the scheduled TB in order to calculate Delta-MCS. So it isn’t clear why this is an issue.  [Hw/HiSi]. This is the reason why we would like that different characteristics are discussued together, i.e. that design choices can be avoided that would risk to turn out into an inefficient feature.  It is true as you said that in principle the UE does not need to know the BLER target of the scheduled TB, the delta-MCS could be calculated for some reference BLER. But this could result into a large required UL overhead since the gNB might use another BLER when scheduling the TB. In this situation, there would be a MCS offset between the MCS obtained at the UE side and the MCS used for scheduling the TB. If the group would then agree to use the MCS of the scheduled MCS as the reference for the delta-MCS report, then there would be many bits required to represent the “delta”. For example, depending on the size of the MCS offset, a delta-MCS=7 could mean “go down with MCS” and a delta MCS=9 could mean go up with the MCS. I hope that this clarifies the issue. |
| Futurewei | No | We shared the same view as Intel that only one of Case 1 or Case 2 schemes should be supported. Based on our evaluation results, Case 1 scheme provides much better performance than delta-MCS scheme. Furthermore, Case 1 scheme has much less spec impact. Therefore, Case 1 scheme should be supported and delta-MCS scheme should not be supported. |
| Samsung | Yes |  |
| Apple |  | The testability issue is very key, suggest we clarifying that first. |
| Ericsson | Yes | If only one scheme should be selected for Rel-17, our view is delta-MCS should be supported, and “improved subband CQI granularity” should not be supported. |
| ZTE | Yes | Yes, we think the delta-MCS can be supported. |

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| QC | Yes | Similar view as Ericsson, If only one scheme should be selected for Rel-17, our view is delta-MCS should be supported. As a compromise, we could support both case 1 and case 2 because we don’t see they are mutually exclusive. They can work nicely together to improve the CSI. |
| Quectel | Yes |  |
| vivo | No | we should discuss first the technical details on how to derive and report the delta-MCS and investigate the cost and benefit before making decision on whether to support delta-MCS.  In our opinion, at least following should be clarified and discussed for delta-MCS.   * Whether and how to address the misalignment of target BLER between gNB and UE for derive the delta-MCS? * Performance benefit for delta-MCS should be further justified. According to current input, limited results show benefit and there are also results showing no performance benefit. * How to report delta-MCS and how to trigger delta-MCS report. The potential impacts on HARQ-ACK transmission performance and HARQ-ACK codebook construction in case of same PUCCH resource should be discussed. * It seems the deriving delta MCS is implementation-related. RAN4 test are required for the calculation method for delta-MCS |
| DOCOMO |  | We prefer to discuss the design details of delta-MCS before agreeing on support of it in order to see the cost and benefit. |
| LG |  | We share similar view to DoCoMo. We should discuss more about what delta-MCS would be before determine whether to support. Following has to be indentified.   * Delta-MCS can replace legacy CQI or conduct on the top of legacy CQI? * How many bits are required for delta-MCS? Is the overhead is per TB or per reporting? * How to trigger delta-MCS |
| CATT | Yes |  |
| OPPO | Yes |  |
| MediaTek | No | We have concern on the impact to the UE processing timeline from adopting delta-MCS. So far, none of the companies has evaluated the drawbacks of delaying the HARQ-ACK in order to include the delta-MCS. So, we want to make sure that the UE processing timeline is extended to be able to do the extra calculation for the delta-MCS. Also, given that there is significant spec and UE impact, there current evaluations are not sufficient to justify introducing delta-MCS. |
| CMCC | Y/N | Similar view with DoCoMo and LG because a little more details on delta-MCS design will help the decision on whether or not to support it. Right now companies are not aligned on the simulation assumptions, hence the argument. |
| Moderator |  | Observations:   1. companies (Sony, Samsung, Ericsson, ZTE, QC, Quectel, CATT, OPPO) companies suggest to agree on supporting Delta-MCS now. 2. companies (Nokia, HW/HiSi, Apple, vivo, DoCoMo, LG, Mediatek, CMCC) would prefer to discuss and agree on design details further prior to deciding on whether to support Delta-MCS.   2 companies (Intel, Futurewei) do not agree on supporting Delta-MCS and do not want to discuss further.  Based on the above feedback, one possible way forward is to take a working assumption that Delta-MCS is supported so that we can make progress on the design. |

**Question 2-5**: Please indicate if FL proposal 8.2-1 is acceptable.

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| --- | --- | --- |
| Company | Yes/No | Comments |
| Nokia | Yes |  |
| HW/HiSi | [No] | It might be acceptable if the gNB has the possibility to trigger the delta-MCS report. Then, it can avoid situations where the increased payload of the PUCCH could cause harm, for example a decreased coverage or reliability of the feedback. Otherwise, we prefer to send the delta-MCS on a separate PUCCH.  We think for the sake of progress, it would be beneficial to discuss the delta-MCS triggering, the resources and the target BLER together. |
| Intel |  | If RAN1 could not conclude on support/not support of delta-MCS, we are fine to limit the scope of the discussion to HARQ-ACK based reporting |
| Sony |  | We think this would benefit from a bit more discussion. There are benefits from sending it on the PUCCH carrying HARQ-ACK and on a separate PUCCH/PUSCH channel. As some companies suggested, multiple TBs’ delta-MCS can be combined, e.g. taking the average, and sent on a separate PUCCH/PUSCH channel which may reduce overhead. |
| Futurewei | No | We suggest making decision on whether delta-MCS scheme should be supported first before agreeing on the design details of the scheme. |
| Samsung | Yes | Using a separate channel and defining delta\_MCS as another UCI type would have at least the following problems:   1. Require new collisions resolution procedures for the UE/gNB. 2. Require new multiplexing procedures in PUSCH/PUCCH, on top of what is being discussed in intra-UE multiplexing. 3. For TDD systems, it would never exist in practice unless the gNB accepts scheduling restrictions or unless coverage is reduced by having PUCCH resources for HARQ-ACK and PUCCH resources for delta\_MCS in different symbols of a slot. 4. Would require substantial specification support.   None of the above is either necessary or acceptable to support delta\_MCS. Also, an “average” delta\_MCS would not provide any gains, if at all meaningful for a gNB to interpret and use for scheduling decisions. |
| Apple | Yes |  |
| Ericsson | Yes |  |
| ZTE | Yes | We are fine with this proposal. |

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| --- | --- | --- |
| QC | Yes |  |
| Quectel | Yes |  |
| vivo |  | We understand this proposal is helpful for coverging the delta-MCS discussion. But we think more clarification on this proposal is needed. Because if delta-MCS is using the same reporting resource with HARQ-ACK, it should be clarified whether delta MCS can be included in type 1 or type 2 HARQ-ACK codebook and what is the impact on the HARQ-ACK codebook construction.  On the other hand, as Huawei mentioned, HARQ-ACK performance in case of reporting delta-MCS and HARQ-ACK in the same PUCCH should be considered. The impact on the HARQ-ACK reliability needs to be evaluated.  Thirdly, if delta-MCS and HARQ-ACK are reported in the same PUCCH, there may be issue on the PDSCH processing time since UE needs to process PDSCH decoding, HARQ-ACK preparing and delta-MCS derivation. Could you explain whether and how to address the timeline issue? |
| DOCOMO | Yes |  |
| LG | No | We would like to discuss more about what delta-MCS would be, before determine whether to support. |
| CATT |  | We think it may be related to the triggering scheme and would like to have some discussion before agreeing to it. |
| OPPO | Yes |  |
| MediaTek | No | If delta-MCS is reported in the same resource as HARQ-ACK, the UE processing timeline need to be extended. |
| CMCC | No | Maybe more discussions are needed before the decision. Try to catch people’s concerns here:   * + - 1. It can not affect traditional HARQ functionality       2. It should not cost too much overhead       3. It can be switched on/off (maybe? Because of the above 2 bullet points)   It can serves statistically (i.e. many TBs 🡪 1 delta-MCS) |
| Spreadtrum | Yes |  |
| Moderator |  | @HW/HiSi: The proposal does not imply that delta-MCS would be transmitted for every TB. The control of whether to report for a TB is a separate issue.  @Sony, LG: I agree there could be potential benefits to sending in separate resource, including possibility of averaging which could be useful for OLLA. However, given strong majority in favor of sending in same resource as HARQ-ACK (and also that this would be needed anyway to provide information for immediate retransmission), we should support at least this case.  @vivo: For the supported codebook type this can be discussed in a next step. OK to add FFS on this.  @Mediatek: OK to add FFS on the UE processing timeline extension. |

**Question 2-6**: Please indicate if FL proposal 8.2-2 is acceptable.

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Nokia | Partly | When gNB scheduling TBs, gNB use different BLER targets for different TBs and it is not fully feasible to assume that only two BLER targets will be used by the gNB towards the UE.  If the UE assumes a fixed BLER target which is different from the target that gNB schedule the TB, report of delta-MCS may not be useful. We are not sure this was checked in the simulation studies.  However, indicating used BLER target may not be fully reasonable as well. We also think this is related to which PDSCHs that the UE suppose to feedback the delta-MCS as reporting delta-MCS to all PDSCHs may be not useful due to extra overhead. So, prior agreeing to this, it is better we discuss 8.2.-3 or discuss everything in a single proposal. |
| HW/HiSi | No | Making a decision now on which target BLER the UE shall assume can result into an inferior design in the later stages of this discussion. For example the UL overhead could become high or the gNB scheduling flexibility would be restricted.  Before discussing this proposal, we should therefore decide whether the UE should be made aware of the target BLER that the gNB is using when scheduling the TB. |
| Intel | No | Although we are not supportive of the overall delta-MCS reporting mechanism, we need to point out that an MCS table was never associated with a target BLER to allow eNB/gNB scheduling flexibility. Thus, it is unclear how to select a value and how it can be used when reported. |
| Sony | Maybe | We can start with 2 BLER targets as working assumption.  We think we do not need to tie it to an MCS table as this is rather limiting. The gNB can ask for a delta-MCS with target BLER = 10-5 for an eMBB PDSCH and we do not see why we need to stop the gNB from doing this.  Our suggestion is:  **Support at least two target BLER applicable to Delta-MCS calculation** |
| Futurewei | No | We suggest making decision on whether delta-MCS scheme should be supported first before agreeing on the design details of the scheme. |
| Samsung | Yes | A gNB can target different BLERs for transmissions of different TBs. Whether another BLER is configured by RRC would not make a difference. The only thing that matters is what MCS range the delta\_MCS can cover. As the entries in the MCS table are separated by about 0.9 dB and as it is not meaningful to have granularity of 1 MCS entry in the delta\_MCS reporting, having a granularity of 2-3 MCS entries can capture a large SINR range to cover any actual BLER using 2 bits for delta\_MCS. Alternatively, the DCI can indicate the BLER of the TB but that would require ~2 additional bits in the DCI and cannot be supported by DCI 1\_0 or for SPS PDSCH. For the above reasons, we support proposal 8.2-2. |
| Apple | No | **Our preference is to have a single BLER target, also we**  don’t see the point to have “**Target BLER depends at least on MCS table used for the TB**   * + **FFS: whether value for each MCS table is fixed or configured by RRC.”** |
| Ericsson | Maybe | For the first bullet, we are fine with at least supporting BLER=1e-1 and 1e-5.  For the second bullet, it is premature to decide that the target BLER depends on the MCS table used to schedule the TB. It is more reasonable that gNB configures the target BLER that the UE should report delta-MCS for. For example, in current spec, gNB can schedule PDSCH using MCS table of one BLER target (1e-1), and request CQI for another BLER target (e.g., 1e-5) |
| ZTE |  | We are fine with the values in the first bullet for the target BLER and it can be configured by the network. |

|  |  |  |
| --- | --- | --- |
| QC | Yes |  |
| Quectel | Yes |  |
| vivo |  | We think defining the target BLER for UE to determine the delta-MCS will put restriction on gNB scheduling. In fact, for a PDSCH scheduling, how to determine the MCS is up to gNB implementation. Therefore, UE cannot be aware of the actual BLER target for the MCS indicated by gNB for a PDSCH transmission. So, there would be always some difference between the obtained MCS from CQI reporting based on configured BLER target and the applied MCS from gNB based on the actually used BLER target. It would be difficult for UE to determine the accuracy delta MCS value due to uncertainty of the BLER target applied at the gNB side.  In addition, the performance for defining the target BLER applicable to Delta-MCS calculation is not justified. |
| DOCOMO | Partly | We are fine with the first bullet. For the second bullet, we share similar view with Ericsson. |
| LG | Maybe | We are fine with the first bullet. However, considering dynamic MCS table indication, mapping between MCS table to BLER target may bring DCI missing issue. To resolve this issue, we would like to add one more FFS; default target BLER for dynamic MCS table indication. |
| OPPO | Yes on 1st bullet | The 2nd bullet seems need more discussion. |
| CMCC | YES | We think the point of current proposal is the standalization efforts.  It is better to decouple the scheduled MCS table with target BLER, if time allows. Like many companies sugguest.  It is even better to have more target BLER value available.  Overall we are supportive to this proposal as a starting point. |
| Spreadtrum | Partially Yes | We support the first sub-bullet, and OK with these two values.  The 2nd bullet needs further clarification. |
| Moderator |  | @Nokia, HW/HiSi, vivo: I understand the concern about network targeting a BLER that is not exactly what the UE assumes for the calculation of delta-MCS but there is a trade-off to consider, e.g. with UE complexity to support evaluation with multiple possible BLER targets or signaling cost of dynamically indicating used BLER target.  @Apple: Understand that you would prefer single BLER target supported. However, many companies would prefer more flexibility so this is a compromise.  @Intel, Sony, Ericsson, Apple, DOCOMO, LG, Oppo, Spreadtrum: Note that there would be no restriction if the target BLER is configurable for each table (the network could configure 1e-5 or 1e-1 for both tables). However, one benefit of the tie-in would be to allow the network to get information dynamically for more than 1 target BLER. This being said, fine to put the second bullet as FFS. |

**Question 2-7**: Please indicate if FL proposal 8.2-3 is acceptable.

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Nokia | Partly | Not sure what is covered by “per TB”.  We do not think 1-bit report for all TBs are needed as that will add unnecessary overhead to the reporting of HARQ. Also as gNB uses different BLER targets, gNB may not get any useful feedback at the end. As the report is only needed for OLLA and may be for retarnmission (less useful), we do not have to consider all TBs when deriving feedback information. Having said that, we agree that, if delta-MCS is reported for a given TB, it can be a single bit. |
| HW/HiSi | [No] | Could it be clarified: is the intention with “at least 1-bit per TB” that the delta-MCS report is always on, i.e. a delta-MCS must be reported for each TB?  If this is the case, then we are not supportive, similar to Nokia, we also think that there are situations when a delta-MCS is not needed, or even could degrade the performance. It should be up to the gNB when to request a delta-MCS report. |
| Intel |  | Although we are not supportive of the overall delta-MCS reporting mechanism, we agree to evaluate further assuming at most 1-bit added to HARQ-ACK |
| Sony |  | We think that not all TBs require a delta-MCS report. If we support combining (e.g. average) multiple TBs’ delta-MCS into one report, then we may want more bits for that report. |
| Futurewei | No | We suggest making decision on whether delta-MCS scheme should be supported first before agreeing on the design details of the scheme. |
| Samsung |  | The proposal does not seem necessary. The “at least one bit per TB” is practically a given (for TBs with delta\_MCS). The number of bits should be configurable to whatever the gNB wants them to be (within reason – e.g. 1, 2, 3) – there is no justification for hard-coding.  We also support to discuss not having delta\_MCS reported for every TB and to have delta\_MCS be the HARQ-ACK because the ACK/NACK value and the delta\_MCS value are directly linked. |
| Apple |  | We don’t need to dicuss this proposal until bigger issues are handled. |
| Ericsson | Maybe | We support the intention of FL proposal 8.2-3. To address the concern that delta-MCS may not be reported per TB, the proposal can be modified by adding “if reported for the given TB”. |
| ZTE |  | We are fine with this proposal if here we only discuss the number of the bits for the delta-MCS and the intention is to support the 1 bit delta-MCS for a TB. For the other aspect, e.g., delta-MCS report for a TB or multiple TBs, it should be further discussed. |

|  |  |  |
| --- | --- | --- |
| QC | Yes |  |
| Quectel | Yes |  |
| vivo | No | We should discuss how to derive and report the delta-MCS first before determining the number of bits for delta-MCS. |
| DOCOMO | Maybe | We share the same concern on overhead due to unnecessary delta-MCS report. The suggestion from Ericsson should solve the concern. We are fine with the proposal with the modification. |
| LG |  | We should discuss first how to generate delta-MCS reporting bit per TB or per PUCCH. |
| CATT |  | The number of bits should be further discussed. Our preference is to have at least 2 bits. |
| OPPO | Not now | It seems premature to agree on 1-bit. In addition, if the number of bits is quite limited (like what is proposed here), it is better to clarify the associated code-points. More discussion are needed. |
| MediaTek | No | Agree with vivo’s view. |
| CMCC | Y/N | Yes for aligning the simulation, no for the actual system design because it’s a little early. |
| Spreadtrum | No | We do not think every TB needs delta-MCS. It can be controlled by gNB. |
| Moderator |  | @All, the intention was not to force that delta-MCS is reported for every TB. I can clarify using Ericsson suggestion.  @Sony, Samsung, CATT, OPPO, CMCC: This proposal does not preclude more than 1 bit but since most evaluations assumed 1 bit and it is supported by largest number of companies, this seems to be a good starting point. |
| Apple2 |  | Let us clarify the testability issue here. For CQI feedback, assumptions taken by the UE are specified in 38.214, copied below for your reference. For Delta-MCS, we should also establish similar conditions. |

Based on the discussion, the FL proposals are merged and updated as follows:

**FL proposed working assumption 8.2-4**

**Support reporting of delta-MCS:**

* **Report consists of delta-MCS for a TB received with MCS index IMCS:**
  + **delta-MCS is calculated from the difference between IMCS\_tgt and IMCS, where IMCS\_tgt is the largest MCS index such that the estimated BLER for a TB received with this MCS index would be smaller than or equal to a BLER target, and IMCS is the MCS index of the received TB.**

**FL proposal 8.2-5**

* **Delta-MCS is reported in same resource as HARQ-ACK**
  + **FFS: Whether HARQ-ACK and Delta-MCS for a TB can be jointly encoded (multi-bit HARQ-ACK)**
  + **FFS: Supported HARQ-ACK codebook types**
  + **FFS: Required extension of UE processing timeline**
* **Support values {1e-1;1e-5} for the target BLER applicable to Delta-MCS calculation**
  + **FFS: additional values**
  + **FFS: Target BLER depends at least on MCS table used for the TB**
* **Support at least the case of 1 bit per TB (in addition to HARQ-ACK and if reported for the given TB)**
  + **FFS: More than 1 bit**
  + **FFS: Mapping to Delta-MCS values**
  + **FFS: Condition(s) for reporting Delta-MCS for a TB**

## E-mail discussion (2nd round) for Topic #2

The above proposals were quickly presented at GTW but due to limited time available only one comment could be made.

**Question 2-8**: Please indicate if FL proposal 8.2-4 is acceptable.

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Apple |  | It seems our input to round 1 in version 25/26 is missing. I add it back to the end of Section 8.3, where the commitment from the UE to gNB is clarified. We understand FL wants to have more structured discussion. The two proposals address the “How” aspects, but not the “what” aspects of CSI enhancement, that is even more important (e.g. whether it is for initial transmission or retransmission, etc). We should try to clarify the “what” aspects . |
| QC | Yes |  |
| vivo | No | As we commented earlier, we should discuss first the technical details for delta-MCS and investigate the cost and benefit before making decision on whether to support delta-MCS.  The key aspects that need to be discussed at least include   * Whether delta-MCS can be used for scheduling a new Tx, or just for retransmission? It will impact the design of delta-MCS. * Whether and how the delta-MCS can be used for a next Tx on the different subbands * What target BLER will UE assume to determine delta-MCS? What is needed to ensure the accuracy and usefulness for delta-MCS derived by UE, considering there could be misalignment of target BLER between gNB and UE? * What impact on the UE processing timeline will the delta-MCS derivation cause is unclear. If delta-MCS is reported with HARQ-ACK in the same PUCCH, whether a new timeline needs to be defined or reusing the existing CSI timeline? It seems the timeline issue has not been discussed yet. We think this issue needs to be discussed and how much impact should be evaluated. * What will be difference to derive delta-MCS for retransmission or for new Tx (if supported). Is HARQ combining taken into account for determining delta-MCS for retransmission? Whether the target BLER to determine delta-MCS for retransmission or new Tx is different? * Whether delta-MCS is reported in joint/separate resource with HARQ-ACK? Whether delta MCS can be included in type 1 or type 2 HARQ-ACK codebook and what is the impact on the HARQ-ACK codebook construction. * Whether to report for every PDSCH and how to handle delta MCS for multiple PDSCHs. |
| Intel | No | Prefer to continue looking into all implications and performance impact from delta-MCS reporting feature before making an agreement. |
| CATT | Yes |  |
| ZTE | Yes | We support this proposal. |
| Futurewei | No | Our performance results show that delta-MCS cannot provide performance gain and actually lead to performance loss. Some performance evaluation results submitted in this meeting and in previous meeting also show the same trend. Given that 4-bit subband CQI is agreed, which can provide much better performance than delta-MCS, and considering that there are still many open issues for delta-MCS, we don’t think delta-MCS should be supported. |
| Nokia | Partly | We do not think the proposal is mature enough yet to support it without agreeing to basic framework. We would be ok with the following.  **FL proposed working assumption 8.2-4**  **For ~~Support~~ reporting of delta-MCS:**   * **Report consists of delta-MCS for a TB received with MCS index IMCS:**   + **delta-MCS is calculated from the difference between IMCS\_tgt and IMCS, where IMCS\_tgt is the largest MCS index such that the estimated BLER for a TB received with this MCS index would be smaller than or equal to a BLER target, and IMCS is the MCS index of the received TB.** |
| Sony | Yes | We would prefer to agree to the proposal. If companies have concerns with the specs implications, then we should set this as Working Assumption as firstly proposed by the FL. We believe this is a fair approach and a good step forward. |
| HW/HiSi | No | We share the views from vivo and Intel in general. Especially, we would like to discuss the following before making any decisision on support   * Shall the delta-MCS be triggered dynamically and separately from HARQ-ACK? * How to address a potential target BLER mismatch between the scheduled TB and the assumed target BLER at the UE side and what implications does it have, for example on signaling and required UL overhead? * What reference to use for the “delta”?   Impact on the processing time-line, especially important if HARQ-ACK and delta-MCS should be sent on the same PUCCH. An evaluation of the processing time could be more complicated than for the partial-CQI update |
| LG | Partly | Comparing to 4 bit CQI reporing, delta-MCS still has a lot of remaining point to identify how the scheme works. As contibutions provided in this meeting, it would be first to discuss about technical details. |
| Lenovo, Motorola Mobility |  | Agree with Vivo and Apple that discussing the applicability of delta\_MCS to initial or retransmission of a TB is important. |
| MediaTek | No | Agree with the comments from vivo |
| spreadtrum | partly | We prefer the version from Nokia. |
| DOCOMO | Partly | We share the same view as Nokia and prefer the version from Nokia. |
| Quectel | Yes |  |

**Question 2-9**: Please indicate if FL proposal 8.2-5 would be acceptable (under condition that Delta-MCS is agreed to be supported).

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Apple |  | It seems our input to round 1 in version 25/26 is missing. I add it back to the end of Section 8.3, where the commitment from the UE to gNB is clarified. We understand FL wants to have more structured discussion. The two proposals address the “How” aspects, but not the “what” aspects of CSI enhancement, that is even more important (e.g. whether it is for initial transmission or retransmission, etc). We should try to clarify the “what” aspects . |
| QC | Yes |  |
| vivo |  | We should discuss first the technical details for delta-MCS as the comment for Question 2-8. |
| Intel |  | We are fine to work on the details of the delta-MCS reporting to see all implications and performance benefits, without directly agreeing on the feature.  With that in mind, bullets 1 and 3 are acceptable to shape the feature for further study and analysis. However, for bullet 2 there was very little technical discussion, but it has very high implications on potential performance. Thus, more discussion is required for bullet 2. |
| CATT | partial | We are fine with the first two bullets and would like to keep the number of bits FFS. We understand that the current proposal does not preclude more than 1 bits, but keep the possiblity that we only agree one value with more than 1 bits for now. |
| ZTE | Yes | We are fine with the proposal. |
| Futurewei | No | Our performance results show that delta-MCS cannot provide performance gain and actually lead to performance loss. Some performance evaluation results submitted in this meeting and in previous meeting also show the same trend. Given that 4-bit subband CQI is agreed, which can provide much better performance than delta-MCS, and considering that there are still many open issues for delta-MCS, we don’t think delta-MCS should be supported. |
| Nokia | Partly | We are fine with the following update based on following justification,   * Delta-MCS should further investigated, but details can be agreed subjectively. * We do not know what is refer as multi-bit HARQ-ACK as this delta-MCS is not HARQ-ACK reporting. So wording that is not related should not be used. Also, if the first sub-bullet is FFS, we can not list another sub-bullet covering what to do with different HARQ codebooks. * We do not think there is time to do any timeline extensions in Rel-17. So, no studies are needed on that. * We do not think assuming fixed BLER targets are useful when the gNB scheduling a BLER targets are different for different TBs. If the UE uses 10-5 BLER target, but the gNB schedule 10-1 TB target BLER, what is the use of delta-MCS reporting. Without assuming a correct BLER target as used at the gNB, we do not think the scheme is useful. Companies should provide details on that. We do not think semi-static configuring numbers for those helps. * Also, we shall agree that only sub-set of TBs are required to report this delta-MCS.   **FL proposal 8.2-5 If delta-MCS is supported, use the following,**   * **Delta-MCS is reported in same resource as HARQ-ACK**   + **FFS: Whether HARQ-ACK and Delta-MCS for a TB can be jointly encoded ~~(multi-bit HARQ-ACK)~~**   + **~~FFS:~~ ~~Supported HARQ-ACK codebook types~~**   + **~~FFS: Required extension of UE processing timeline~~** * **Support ~~values {1e-1;1e-5} for~~  the UE determining the ~~the~~ target BLER applicable for for Delta-MCS calculation for a TB**   + **FFS: How to indicate/derive correct BLER target for a scheduled TB**   + **FFS: ~~additional~~ supported BLER target values (10-1, 10-2, ..)**   + **~~FFS: Target BLER depends at least on MCS table used for the TB~~** * **Support ~~at least~~ the case of 1 bit per TB (in addition to HARQ-ACK and if reported for the given TB)**   + **Delta-MCS is reported only for a sub-set of scheduled TBs.**   + **FFS: More than 1 bit**   + **FFS: Mapping to Delta-MCS values**   + **FFS: Condition(s) for reporting Delta-MCS for a TB** |
| Sony | Yes |  |
| HwHiSi | No | Can it be clarified if the assumption of this proposal is that delta-MCS already is supported?  For the first bullet, we think the decisive questions are in the FFS and which way to go in the main-bullet depends on the outcome of the FFS. For example, the performance of HARQ-ACK shall not be degraded in our view (reliability and latency shall be preserved). Thus, if the delta-MCS should be sent in the same PUCCH as HARQ-ACK, then the processing time must be ensured and it should be possible to trigger/disable delta-MCS dynamically by the gNB.  For the second bullet, the important questions are how to deal with a potential BLER mismatch between the scheduled TB and the UE. If the UE uses a fixed BLER for the calculation, then there can be an MCS offset between achievable MCS calculated at the UE and the used MCS at the gNB. This can then result into a large required UL overhead. We prefer to have this discussion first to get every company onto the same page before making a decision on the supported target values.  For the third bullet, it should firstly be decided on which conditions and how the delta-MCS is reported for a TB. Is the period semi-statically configured, is it dynamically triggered, is it always on? Overall, the number of bits should be low, but instead of agreeing on “at least 1 bit”, we think it is more meaningful to focus on the functionality that would allow us this low overhead. |
| LG | Partly | We have concern on third bullet. Considering delta-MCS is conveyed with HARQ-ACK codebook, delta-MCS per TB would make a lot of signaling overhead. Before determine whether to generate delta-MCS per TB or not, we should discuss how delta-MCS is triggered and how UE reports delta-MCS once triggered. |
| Lenovo, Motorola Mobility | OK | We think, “if supported”, the proposal is a good starting point for details. |
| MediaTek | No | The BLER target need to configurable and has wider range (e.g. 1e-1, 1e-2, 1e-3, 1e-4, 1e-5). Also, it is expected that the gNB will use different BLER targets for the initial transmission and retransmission (e.g. 1e-1 for 1st-Tx and 1e-4 for re-Tx). Hence, the gNB should be able to configure different BLER targets to be used for delta-MCS calculations.  If delta-MCS is reported in same resource as HARQ-ACK, the UE processing timeline need to extended (adding FFS is not sufficient). |
| Spreadtrum | Yes |  |
| DOCOMO | Yes |  |
| Quectel | Yes |  |

Moderator comments:

Moderator understands the performance-related concerns from Futurewei. However, the decision to support or not should not be based solely on Futurewei’s results. Other companies have provided results that show benefit.

For the “initial vs retransmission” issue, moderator’s understanding is that both use cases can be supported as companies identified benefits for both.

Moderator’s understanding is that whether the network retransmits on same or different subband is a network implementation issue. This does not affect the design of delta-MCS. One should note that RAN1 already agreed in RAN1#103-e that for Case 2 the measurement is based on PDSCH. Therefore, what the UE reports can only be based on measurements from received PDSCH carrying a TB. The UE also needs to assume same transmission parameters as the received PDSCH except for IMCS and possibly adjustment of frequency or time allocation to maintain same TB size. It can be further studied whether the calculation is based on combined PDSCHs or only latest PDSCH for the TB which has been mentioned by several companies in contributions. To reflect this, moderator proposes to agree on the following:

**FL proposal 8.2-6**

**For reporting of delta-MCS (if supported):**

* **Report consists of delta-MCS for a TB received with MCS index IMCS:**

**delta-MCS is calculated from the difference between IMCS\_tgt and IMCS, where IMCS\_tgt is the largest MCS index such that the estimated BLER for a TB received with this MCS index would be smaller than or equal to a BLER target, and IMCS is the MCS index of the received TB.**

**The UE determines delta-MCS for a TB based on the received PDSCH(s) for the TB.**

* **The UE assumes a PDSCH with same transmission parameters as the latest received PDSCH for the TB (except IMCS)**
  + **FFS: Adjustment of frequency or time allocation for constant TB size**
* **FFS: whether UE considers all received PDSCHs for the TB, or only latest received PDSCH for the TB.**

For the reporting resource, there is large majority of supporting companies that prefer to report on same resource as HARQ-ACK, not only because it works for both initial/retransmission use cases but also avoids a lot of complexity with provisioning separate resource. Moderator’s view is that the best that can be done is to agree on reporting on same resource as HARQ-ACK if delta-MCS is supported and then make further agreements to address these concerns. It can also be left open if additionally, reporting in separate resource can be supported.

For the BLER assumption/mismatch, it seems fair to have more discussion on this since not all companies discussed this issue in detail in contributions. Same can apply to the number of bits per TB.

Taking into account the comments, moderator proposes to agree on the following:

**FL proposal 8.2-7**

**If Delta-MCS is supported, the following applies:**

* **Delta-MCS can be reported in same resource as HARQ-ACK**
  + **Support means for network to control/trigger whether Delta-MCS is reported in a resource in which HARQ-ACK is reported**
  + **Support relaxation of PDSCH processing time requirement when Delta-MCS is reported (FFS value)**
  + **Delta-MCS is reported only for a subset of received TBs**
  + **FFS: Whether HARQ-ACK and Delta-MCS for a TB can be jointly encoded ~~(multi-bit HARQ-ACK)~~**
  + **FFS: Number of bits per TB**
  + **FFS: Whether reporting of Delta-MCS in resource separate from HARQ-ACK (PUCCH, MAC CE, etc.) and/or combining/averaging of Delta-MCS can also be supported.**
* **The UE determines the applicable target BLER for each TB**
  + **FFS: How to indicate/derive applicable BLER target for the TB**
  + **FFS: Supported BLER target value(s) (e.g. 10-1, 10-2, ..10-5)**

## E-mail discussion (3rd round) for Topic #2

**Question 2-10**: Please indicate if FL proposals 8.2-6 and 8.2-7 are acceptable (you may reply separately for each).

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Samsung | No | Do not agree with the red text of 8.2-6.  Do not agree with 8.2-7  It should be FFS whether relaxation in PDSCH processing time is needed. It should not be mandated that delta\_MCS is reported for a subset of TBs  Reporting delta\_MCS separate from HARQ-ACK would introduce unacceptable specification and implementation impact as previously stated and repeated below.  %%%%  Using a separate channel and defining delta\_MCS as another UCI type would have at least the following problems:   1. Require new collisions resolution procedures for the UE/gNB. 2. Require new multiplexing procedures in PUSCH/PUCCH, on top of what is being discussed in intra-UE multiplexing. 3. For TDD systems, it would never exist in practice unless the gNB accepts scheduling restrictions or unless coverage is reduced by having PUCCH resources for HARQ-ACK and PUCCH resources for delta\_MCS in different symbols of a slot. 4. Would require substantial specification support.   None of the above is either necessary or acceptable to support delta\_MCS. Also, an “average” delta\_MCS would not provide any gains, if at all meaningful for a gNB to interpret and use for scheduling decisions.  %%% |
| QC | Partially YES | For FL proposal 8.2-6, we don’t agree with the following part:  **The UE determines delta-MCS for a TB based on the received PDSCH(s) for the TB.**   * **The UE assumes a PDSCH with same transmission parameters as the latest received PDSCH for the TB (except IMCS)**   + **FFS: Adjustment of frequency or time allocation for constant TB size**   **FFS: whether UE considers all received PDSCHs for the TB, or only latest received PDSCH for the TB.**  First of all, we are also puzzled what is the intention of “The UE assumes a PDSCH with same transmission parameters as the latest received PDSCH for the TB (except IMCS)”. Does this means UE use all the parameters in the latest receiverd PDSCH for the TB (except the I\_MCS) to calculate the delta\_MCS? If so, maybe it is better rephrase this bullet to make this point clearer?  Regarding the “FFS: whether UE considers all received PDSCHs for the TB, or only latest received PDSCH for the TB.”: can FL clarify if this is for the case of delta MCS report for a PDSCH which retransmit a TB? In this case, UE need to decide the target MCS calculation is only based on this PDSCH or this PDSCH + previous PDSCH for the same TB? If the intention of the FFS is to further discuss this case, then we think the FFS is fine.  For FL proposal 8.2-7: we don’t agree with the following bullet.  “Delta-MCS is reported only for a subset of received TBs”: we agree with Samsung this restriction is not necessary. The first sub-bullet already support means for NW to trigger delta-MCS is reported for a TB or not. Then it is up to NW to trigger it or not. No need to put this restriction in spec.  A minor comment on “The UE determines the applicable target BLER for each TB”: I think this is not purely determined by the UE. NW signaling also play a role in this determination. |

In addition, to continue the discussion on aspects listed as FFS, moderator proposes that companies provide input to following questions.

**Question 2-11**: For the target BLER assumption, please indicate your views on the following:

* What would be a reasonable number possible target BLER values that can be supported, considering UE implementation complexity versus network flexibility?
* What set of values do you recommend?
* Is it necessary to have the ability to dynamically indicate the target BLER for a delta-MCS? If yes, how should this be done (MCS table, priority indication, explicit indication, etc.)

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Samsung |  | The BLERs of the MCS tables from Rel-16 (10-1 and 10-5) are sufficient. No issue with a gNB targeting arbitrary BLER for each TB.  No need to dynamically indicate BLER target. It also does not work for SPS PDSCH or for DCI 1\_0. |
| QC |  | Same view as Samsung 10^-1 and 10^-5 BLER targets are good enough.  Just associate the BLER target with the MCS table seems good enough. No additional signaling is needed. |

**Question 2-12**: Please indicate what should be supported to ensure that the network can control/trigger whether Delta-MCS is reported for a TB. Please check options listed under “Issue #2-5” of this summary and any other option.

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Samsung |  | Of course the NW can configure a UE whether or not to provide delta\_MCS. Beyond that, there can be many ways to control the number of bits for the delta\_MCS but that is a lower level detail and there is no apparent need to decide now – any workable option can be OK. For example,   1. DCI can indicate whether a configured number of bits (for delta\_MCS) is to be included in the HARQ-ACK report – those bits can be applicable for the delta\_MCS of a corresponding number of first/last TBs (if not all TBs can have delta\_MCS). 2. UE can be configured to report delta\_MCS for each TB until the resulting payload (with HARQ-ACK) is not larget than a configured value (if not enough bits, delta MCS can be reported with priority with respect to first or last received TBs). |
| QC |  | Overall, we feel it is a little too early to discuss the signaling details to enable delta-MCS report. But a simple scheme such as add 1 bit in DCI to diable/enable delta-MCS report can be utilized. |

**Question 2-13**: Please indicate what size(s) of Delta-MCS reports should be supported in terms of number of bits. Please assume no averaging/combining of multiple Delta-MCS reports for this question. If you think there is a dependency on one of the other aspects, please indicate.

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Samsung |  | Configurable (up to N bits – e.g. N=3) – up to the gNB according to each UE’s situation/channel/data rates/CA/etc. No need for RAN1 to fix a number.  No dependency with averaging and no need/reason to support averaging. |
| QC |  | 1 bit is the baseline. We are open to discuss more than 1 bit. But more than 4 bits seems not necessary. |

# Topic #3: Other

Contributions discuss enhancements that do not fall in one of the above categories.

## Summary of issues for Topic #3

**Issue #3.1**: Support A-CSI on PUCCH

Yes : Huawei [2], NTT DoCoMo [22]

* No extra PDCCH blind decoding, available number of CCEs for chest, independent successful reception of DL, latency increase for CSI, increase of DL overhead
* Design details [22]
  + New field in DL DCI (formats 1\_1/1\_2) to trigger A-CSI on PUCCH
  + DCI indicates one of a set of resources configured by RRC
  + DCI indicates PHY priority level
  + Multiplex on first actual PUSCH repetition

No: Quectel [8], LG[18]

* Already discussed, no time
* SP-CSI also works [18]

Other issues

* Associate MCS table with priority indicator field value in DCI: Samsung [9]
* Decouple binding between CQI table and target BLER [17]
* Per-serving cell configuration of target BLER [17]

## E-mail discussion (1st round) for Topic #3

TBD

# References

1. RP-210854 Revised WID: Enhanced IIoT and URLLC support for NR, Nokia, Nokia Shanghai Bell.
2. R1-2106491 CSI feedback enhancements Huawei, HiSilicon
3. R1-2106587 CSI feedback enhancements for Rel-17 URLLC vivo
4. R1-2106679 CSI Feedback Enhancements for IIoT/URLLC Ericsson
5. R1-2106698 Discussion on CSI feedback enhancements Spreadtrum Communications
6. R1-2106735 Discussion on CSI feedback enhancements for eURLLC ZTE
7. R1-2106802 Considerations on CSI enhancements for URLLC Sony
8. R1-2106837 Discussion on CSI Feedback Enhancements Quectel, Langbo
9. R1-2106880 UE Feedback Enhancements for URLLC Samsung
10. R1-2106963 CSI feedback enhancements CATT
11. R1-2107019 CSI feedback enhancements for URLLC/IIoT use cases Nokia, Nokia Shanghai Bell
12. R1-2107074 CSI feedback enhancements InterDigital, Inc.
13. R1-2107078 CSI feedback enhancements for URLLC FUTUREWEI
14. R1-2107185 CSI feedback enhancements for URLLC/IIoT Lenovo, Motorola Mobility
15. R1-2107273 CSI feedback enhancements for URLLC OPPO
16. R1-2107337 CSI enhancement for IOT and URLLC Qualcomm Incorporated
17. R1-2107398 Discussion on CSI feeback enhancements for URLLC CMCC
18. R1-2107444 Discussion on CSI feedback enhancements for URLLC LG Electronics
19. R1-2107492 CSI feedback enhancements for URLLC MediaTek Inc.
20. R1-2107584 On enhanced SB CQI reporting granularity and delta-MCS reporting Intel Corporation
21. R1-2107733 CSI feedback enhancements for URLLC Apple
22. R1-2107852 Discussion on CSI feedback enhancements for Rel.17 URLLC NTT DOCOMO, INC.
23. R1-2108012 Views for Increasing Granularity of Subband CQI ITRI
24. R1-2108237 CSI feedback enhancements InterDigital, Inc.
25. RP-211297 Way forward on CSI feedback enhancements for enhanced URLLC/IIoT InterDigital, Inc., Ericsson, Motorola Mobility, OPPO, Qualcomm, Samsung, SONY, Spreadtrum.

# Appendix: Previous agreements

Guidance from RAN#92-e

(RP-211297)

RAN1 to further investigate the following for CSI enhancements for IIoT/URLLC:

* Increasing the number of bits used for the reported subband CQI (3-bits differential subband CQI or 4-bits CQI)
* Reporting of delta-MCS:
  + Report consists of delta-MCS for a TB received with MCS index IMCS:

delta-MCS is calculated from the difference between IMCS\_tgt and IMCS, where IMCS\_tgt is the largest MCS index such that the estimated BLER for a TB received with this MCS index would be smaller than or equal to a BLER target, and IMCS is the MCS index of the received TB.

Agreements from RAN1#104b-e

**Conclusion:**

For new reporting Case 1, do not consider further the following schemes:

* Case 1-2: CSI prediction
* Case 1-4: Interference covariance matrix
* Case 1-9: Reference wideband CQI excludes worst sub-bands
* Case 1-10: CSI expiration time

Agreements:

For new reporting Case 2, focus study on reporting of delta-CQI/MCS (Case 2-3):

* Note: this delta-CQI/MCS is determined based on UE implementation (for example, using SINR, LLR, raw BER, flipped bits, LDPC iterations, BLEP, # fail parity checks, etc.)
  + Companies are encouraged to provide more details in their analysis
* FFS: Granularity of new report type (e.g. units of CQI or MCS, how many bits)
* FFS: Whether quantity reported is relative to the scheduled MCS

Agreement: Focus study on the following for new reporting Case 1:

* Reporting of new metric, where new metric shall be determined based on network configured channel and interference measurement interval (multiple CMR and/or IMR instances) to enable accurate MCS selection.
  + Downselect by RAN1#105 to at most a single method from the following options:
    - Mean-CQI/SINR and stdev-CQI/SINR (FFS details)
    - CSI based on worst IMR occasion (FFS details)
    - Interference standard deviation (FFS details)
    - Worst-M CQI (FFS details)
  + FFS: Whether network configured channel and interference measurement interval can also be applied to existing CSI type
* Increasing granularity of subband CQI (e.g. 3-bits differential subband CQI or 4-bits full subband CQI).
* Updating only CQI in a report, where CQI is conditioned on a previous instance in which RI/PMI/(CRI) is updated.
  + Applicable for same reporting quantity as R16 for CQI.
  + FFS: Whether network configured channel and interference measurement interval can also be applied
  + FFS: Whether RI/PMI/(CRI) is transmitted in a report where only CQI is updated
  + ~~FFS: how to report the updated CQI~~
  + FFS: whether the CQI processing time can be ~~is~~ reduced compared to Rel-16 CSI processing delay

Final summary in R1-2103956

Agreements from RAN1#104-e

[**R1-2101811**](file:///C:/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_104/Docs/R1-2101811.zip)

**Conclusion:** Continue evaluation of new reporting Case 1 and Case 2 for the schemes identified in Appendix B of [R1-2102131](file:///C:/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_104/Docs/R1-2102131.zip).

* Companies are encouraged to provide their views on each scheme against each criterion in respective Tables in Appendix B.
* Companies are encouraged to provide additional evaluation results for as many schemes as possible, based on assumptions agreed in RAN1#102-e.
* Aim for down-selection at RAN1#104-b-e by taking into account evaluation results and assessment against criteria from Appendix B.

Agreements from RAN1#103-e:

Agreements

* No change of CSI processing time relative to Rel-16 CSI in this WI
* CSI processing time specific to a new CSI reporting quantity/type (if supported) can be studied

Agreement:

* For Case-2 new reporting, continue studying with focus on the new reporting type based on PDSCH decoding for OLLA performance enhancement for initial and re-transmissions of PDSCH.

Agreements:

For Case-1 New reporting, the following candidate schemes have been identified to address the fast interference change over time. Continue studying with focus on the identified schemes below for further study and evaluation.

* Scheme 1a: New reporting quantity based on CQI/SINR statistics, e.g.,
  + CQI/SINR statistics (e.g., mean, variance, etc.)
  + CSI prediction
* Scheme 1b: New reporting quantity of interference statistics (e.g., mean, variance, interference covariance matrix, etc.)
* Scheme 1c: New reporting quantity based on modifying existing reporting format, e.g.,
  + CQI reporting considering the worst subbands
  + Subband CQI granularity enhancement
* Scheme 1d: New reporting quantity related to CSI expiration time
* Scheme 1e: New reporting quantity with partial information update, e.g.,
  + CSI reporting with interference update only

Companies are encouraged to investigate the above schemes, aiming for down-selection in RAN1#104-e

Agreements from RAN1#102-e:

Agreement:

* CSI feedback enhancement for Multi-TRP transmission is not to be discussed further under IIoT/URLLC enhancement WI

Agreements:

* Baseline assumptions are used as the required minimum to be simulated for the evaluation of candidate CSI enhancement schemes
  + Reuse the assumptions in TR 38.824 and TR 38.901 as a starting point
  + Companies shall report additional parameters (e.g., CSI measurement settings, CSI reporting schemes) used in their evaluation
  + FFS details of baseline assumptions
* Companies can bring additional simulation results with other set(s) of assumptions

Agreements:

* Study/evaluate further on following CSI enhancement schemes in terms of technical benefit, specification and implementation impacts.
  + New triggering methods for A-CSI and/or SRS
  + New reporting based on one or more of the following:
    - Case 1: channel/interference measurement for new CSI reporting, considering aspects such as one or more of the following:
      * Reporting more accurate interference characteristics
      * Reduced CSI feedback overhead (e.g., reporting interference measurement only)
      * Enhanced CSI reporting such as WB/SB CQI
    - Case 2: other measurement (other than channel/interference) for additional information
      * E.g., PDCCH/PDSCH decoding, recommended HARQ RV sequence, etc.
    - It targets to help gNB scheduler for better link adaptation of (re)transmission
  + [Reduced CSI computation time/complexity]
  + [CSI feedback for PDCCH]
  + Other CSI enhancement schemes that enable accurate MCS selection are not precluded
* Detailed assumptions of the proposed CSI enhancement schemes should be provided by the proponent, such as
  + Reporting values
  + Triggering conditions for the reporting
  + Associated measurement resource
  + Uplink resource to be used for the reporting
  + How to use the reported information at the gNB scheduler
  + CSI-RS overhead and CSI reporting frequency
  + CSI reporting latency/timeline
  + Etc.

Agreements:

* Consider Table 1 as baseline assumption for system level simulation for evaluating CSI enhancement schemes
  + The uses cases in Table 1 is for simulation purposes and it does not preclude a CSI enhancement scheme which is beneficial for the other URLLC use cases
* No baseline assumption is used for link level simulation
  + Companies are encouraged to use one of LLS assumption tables in Section A.3 in TR38.824 for any link level simulation

**Table 1. Baseline SLS assumption for CSI enhancement schemes in URLLC/IIoT**

|  |  |
| --- | --- |
| **Parameters** | **Values** |
| Performance metric | Option-1 (section 5.1 of TR 38.824)  Additional metrics (it is up to company to bring results with additional metric):   * MCS prediction error (e.g., difference of a scheduled MCS and an ideal MCS) * DL/UL signaling overhead * CCDF of latency samples from all UEs * BLER of 1st transmission * Resource utilization * Spectral efficiency |
| Use cases | Following two use cases can be considered for new triggering method and new reporting. Companies are encouraged to evaluate the following cases in descending priority:   * Rel-15 enabled use case (e.g. AR/VR) in TR 38.824   + Reliability: 99.999   + Latency: 4ms (200bytes)   + Traffic mode: FTP model 3 (100p/s) * Factory automation in TR 38.824   + Reliability: 99.9999   + Latency: 1ms (32bytes)   + Traffic mode: Periodic deterministic traffic model with arrival interval 2ms * Rel-15 enabled use case (e.g. AR/VR) in TR 38.824   + Reliability: 99.999   + Latency: 1ms (32bytes)   + Traffic mode: FTP model 3 (100p/s)   + Assumptions for eMBB and URLLC UEs sharing the same carrier is used (as in A2.5 of TR 38.824) |
| Simulation assumptions | Following simulation assumption is used based on the use case selected:   * Rel-15 enabled use case with UMa (Table A.2.4-1 in TR 38.824) * Factory automation at 4GHz (Table A.2.2-1 in TR38.824) with following update:   + Channel model is replaced with InF (InF-DH) in TR 38.901     - Companies can bring results with other InF scenarios additionally   + Layout is replaced with BS deployment in Table 7.8-7 in TR 38.901 |
| Transmission scheme | Multiple antenna ports Tx scheme   * Companies report the details of Tx scheme used |