3GPP TSG-RAN WG1 Meeting #107-e R1-21xxxxx

e-Meeting, November 11th – 19th, 2021

Agenda Item: 8.9.2

Source: Moderator (Ericsson)

Title: Feature Lead Summary [107-e-LTE-Rel17-NB-IoT-eMTC-02] - first checkpoint

Document for: Discussion and Decision

# 1 Introduction

In the Work Item (WI) on “Additional enhancements for NB-IoT and LTE-MTC” [1], one of the objectives is to specify the following enhancement for LTE-MTC:

|  |
| --- |
| * Support additional PDSCH scheduling delay for introduction of 14-HARQ processes in DL, for HD-FDD Cat M1 UEs. [LTE-MTC] [RAN1] |

This feature lead summary (FLS) collects companies’ views as described in [2-6], classifies technical areas according with the contents in the contributions, and provides potential agreements.

Annex 1 contains the agreements reached in RAN1 #102-e [7], RAN1 #103-e [8], RAN1 #104-e [9], RAN1 #104-bis-e [10], RAN1 #105-e [11], RAN1 #106bis-e [12], and RAN1 #107-e [13].

# 2 FLS on 14 HARQ processes in DL in LTE-MTC

## 2.1 “HARQ-ACK delay set” using Alt-2e

### 2.1.1 Working Assumption on the HARQ-ACK delay sets for Alt-2e

Background: In RAN1 #107-e, the HARQ-ACK delay sets for Alt-2 was left under Working Assumption (WA):

|  |
| --- |
| **Working Assumption**  **For the joint encoding of “PDSCH Scheduling delay” and “HARQ-ACK delay” when Alt-2e is configured, the HARQ-ACK delay set has a size of:**   * **Alt-C:**   + - **12 elements: HARQ-ACK delay set = {a, b, c, d, e, f, g, h, i, j, k, l} for the PDSCH Scheduling delay expression associated to the delay of 2.**     - **10 elements: HARQ-ACK delay set = {o, p, q, r, s, t, u, v, x, w} for the two PDSCH Scheduling delay expressions associated to the delay of 7.**       * **FFS: The values of {a, b, c, d, e, f, g, h, i, j, k, l}, {o, p, q, r, s, t, u, v, x, w} where some of these elements may share the same value.** |

In relation with it, Table 1 summarizes the observations and proposals as in [2-6]:

**Table 1: HARQ-ACK delay sets for Alt-2e according with [2-6]**

|  |  |
| --- | --- |
| **Company** | **Compendium of views on the HARQ-ACK delay set(s) for Alt-2e [2-6].** |
| **Huawei, HiSilicon [2]** | **Proposal 1: The set of HARQ-ACK delay values associated with PDSCH scheduling delay 2 is from 4 to 13, 15, 17, and the set of HARQ-ACK delay values associated with PDSCH scheduling delay 7 is from 12 to 21 if Alt-2e is configured.** |
| **ZTE [3]** | ***Proposal 1: For the joint encoding of “PDSCH Scheduling delay” and “HARQ-ACK delay” when Alt-2e is configured, the HARQ-ACK delay set has a size of:***   * ***12 elements: HARQ-ACK delay set = {4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17} for the PDSCH Scheduling delay expression associated to the delay of 2.*** * ***10 elements: HARQ-ACK delay set = {4, 5, 12, 13, 14, 15, 16, 17, 18, 19}*** ***for the two PDSCH Scheduling delay expressions associated to the delay of 7.*** |
| **Nokia, Nokia Shanghai Bell**  **[4]** | **Proposal 1: RAN1 approve the working assumption for the 12-10 HARQ-ACK delay set sizes for PDSCH delays of 2 and 7 respectively.** |
| **Qualcomm**  **[5]** | **Proposal 1: Confirm the following working assumption:**  **For the joint encoding of “PDSCH Scheduling delay” and “HARQ-ACK delay” when Alt-2e is configured, the HARQ-ACK delay set has a size of:**   * **Alt-C:**   + **12 elements: HARQ-ACK delay set = {a, b, c, d, e, f, g, h, i, j, k, l} for the PDSCH Scheduling delay expression associated to the delay of 2.**   + **10 elements: HARQ-ACK delay set = {o, p, q, r, s, t, u, v, x, w} for the two PDSCH Scheduling delay expressions associated to the delay of 7.**   + **FFS: The values of {a, b, c, d, e, f, g, h, i, j, k, l}, {o, p, q, r, s, t, u, v, x, w} where some of these elements may share the same value.** |
| **Ericsson [6]** | 1. For the joint encoding of “PDSCH Scheduling delay” and “HARQ-ACK delay” when Alt-2e is configured, the HARQ-ACK delay sets are based on Range 2 as follows:  * 12 elements: HARQ-ACK delay set = {4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15} for the PDSCH Scheduling delay expression associated to the delay of 2. * 10 elements: HARQ-ACK delay set = {4, 5, 6, 7, 12, 13, 14, 15, 16, 17} for the two PDSCH Scheduling delay expressions associated to the delay of 7. |

Based the on submitted contributions [2-6], all companies seem to be ok with confirming the Working Assumption (WA) and potential agreement #1 is about it.

**Potential Agreement#1:**

**Confirm the following Working Assumption:**

**Working Assumption**

**For the joint encoding of “PDSCH Scheduling delay” and “HARQ-ACK delay” when Alt-2e is configured, the HARQ-ACK delay set has a size of:**

* **Alt-C:**
  + - **12 elements: HARQ-ACK delay set = {a, b, c, d, e, f, g, h, i, j, k, l} for the PDSCH Scheduling delay expression associated to the delay of 2.**
    - **10 elements: HARQ-ACK delay set = {o, p, q, r, s, t, u, v, x, w} for the two PDSCH Scheduling delay expressions associated to the delay of 7.**

**FFS: The values of {a, b, c, d, e, f, g, h, i, j, k, l}, {o, p, q, r, s, t, u, v, x, w} where some of these elements may share the same value.**

Companies are kindly requested to provide their views below:

|  |  |  |
| --- | --- | --- |
| **Company** | **Is your company OK with confirming the WA as per potential agreement #1?** | **Comments** |
| ZTE, Sanechips | OK |  |
| Ericsson | OK |  |
| Nokia, NSB | OK |  |
| Qualcomm | OK |  |
| NordicSemi | OK |  |
| Lenovo, MotoM | OK |  |
| Huawei, HiSilicon | OK |  |

### 2.1.2 Elements composing the HARQ-ACK delay sets for Alt-2e

For the HARQ-ACK delay sets of Alt-2e, what remains to be done is determining the values of the elements that compose those sets. In relation with it, Table 2 summarizes the observations and proposals as in [2-6]:

**Table 2: Elements in HARQ-ACK delay sets for Alt-2e according with [2-6]**

|  |  |
| --- | --- |
| **Company** | **Compendium of views on the HARQ-ACK delay set(s) for Alt-2e [2-6].** |
| **Huawei, HiSilicon [2]** | **Proposal 1: The set of HARQ-ACK delay values associated with PDSCH scheduling delay 2 is from 4 to 13, 15, 17, and the set of HARQ-ACK delay values associated with PDSCH scheduling delay 7 is from 12 to 21 if Alt-2e is configured.** |
| **ZTE [3]** | ***Proposal 1: For the joint encoding of “PDSCH Scheduling delay” and “HARQ-ACK delay” when Alt-2e is configured, the HARQ-ACK delay set has a size of:***   * ***12 elements: HARQ-ACK delay set = {4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17} for the PDSCH Scheduling delay expression associated to the delay of 2.*** * ***10 elements: HARQ-ACK delay set = {4, 5, 12, 13, 14, 15, 16, 17, 18, 19} for the two PDSCH Scheduling delay expressions associated to the delay of 7.*** |
| **Nokia, Nokia Shanghai Bell**  **[4]** | Whilst we do not have strong opinions about the specific delay set values, we do have the following observations:  **Observation 1: A good delay set will ensure that, when there are no invalid subframes present, the maximum data rate can be achieved.**  **Observation 2:** **A good delay set will ensure that, when not all HARQ processes are required (e.g. less than or equal to 8), high data rates can still be achieved though timely and efficient ACK-NACK bundling (i.e. the minimum number of ACK-NACK bundles are used as early as possible).**  **Observation 3: A good delay set values chosen will ensure that, good data rates are attainable in configurations with up to [20]% invalid subframes** |
| **Qualcomm**  **[5]** | **Proposal 2: The values for the HARQ-ACK delay set are:**   * **Delay of 2 (12 elements): {a, b, c, d, e, f, g, h, I, j, k, l} = {4, 5, 6, 7, 9, 11, 13, 15, 17, 19, 21}** * **Delay of 7 (10 elements): {o, p, q, r, s, t, u, v, x, w} = {4, 6, 9, 11, 13, 15, 17, 19, 21}**   **NOTE: The underlined values are not in ‘range1’ in current TS 36.213.** |
| **Ericsson [6]** | Observation 3: The HARQ-ACK delay set associated to the PDSCH scheduling delay of 7 should include short delay values as to handle scenarios where not all the 14 HARQ processes are in use and to avoid in certain scenarios wating too long for an ACK/NACK.  Observation 4: The introduction of 14 HARQ processes exploits the two unutilized subframes per scheduling cycle in the 10 HARQ processes framework. That is why, in ideal scenarios the maximum required HARQ-ACK delay value passed from 11 subframes to 11+2 subframes = 13 subframes associated to the PDSCH scheduling delay of 7.  Observation 5: Based on the previous observation, the maximum delay value in the 10 elements set under Working Assumption should be equal to the maximum delay value in the 12 elements set plus two.  Proposal 1: For the joint encoding of “PDSCH Scheduling delay” and “HARQ-ACK delay” when Alt-2e is configured, the HARQ-ACK delay sets are based on Range 2 as follows:   * 12 elements: HARQ-ACK delay set = {4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15} for the PDSCH Scheduling delay expression associated to the delay of 2. * 10 elements: HARQ-ACK delay set = {4, 5, 6, 7, 12, 13, 14, 15, 16, 17} for the two PDSCH Scheduling delay expressions associated to the delay of 7. |

Based on the submitted contributions, most of the companies think that the 10 elements HARQ-ACK delay set should also include small or short delay values, one company is neutral, and one other company thinks that the 10 elements HARQ-ACK delay set should only have long delay values. In the potential agreement# 2 the candidate proposals are listed aiming at selecting one of them (Alt-C1 as in [2], Alt-C2 as in [3], Alt-C3 as in [5] (one value seems to be missing in each set), Alt-C4 as in [6]).

**Potential Agreement#2:**

**For the joint encoding of “PDSCH Scheduling delay” and “HARQ-ACK delay” when Alt-2e is configured, the HARQ-ACK delay sets consist of the following elements:**

* **Alt-C1:**
  + - **12 elements: HARQ-ACK delay set = {4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17} for the PDSCH Scheduling delay expression associated to the delay of 2.**
    - **10 elements: HARQ-ACK delay set = {12, 13, 14, 15, 16, 17, 18, 19, 20, 21} for the two PDSCH Scheduling delay expressions associated to the delay of 7.**
* **Alt-C2:**
  + - **12 elements: HARQ-ACK delay set = {4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17} for the PDSCH Scheduling delay expression associated to the delay of 2.**
    - **10 elements: HARQ-ACK delay set = {4, 5, 12, 13, 14, 15, 16, 17, 18, 19} for the two PDSCH Scheduling delay expressions associated to the delay of 7.**
* **Alt-C3:**
  + - **12 elements: HARQ-ACK delay set = {4, 5, 6, 7, 9, 11, 13, 15, 17, 19, 21, ?} for the PDSCH Scheduling delay expression associated to the delay of 2.**
    - **10 elements: HARQ-ACK delay set = {4, 6, 9, 11, 13, 15, 17, 19, 21, ?} for the two PDSCH Scheduling delay expressions associated to the delay of 7.**
* **Alt-C4:**
  + - **12 elements: HARQ-ACK delay set = {4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15} for the PDSCH Scheduling delay expression associated to the delay of 2.**
    - **10 elements: HARQ-ACK delay set = {4, 5, 6, 7, 12, 13, 14, 15, 16, 17} for the two PDSCH Scheduling delay expressions associated to the delay of 7.**
* **Alt-C5:**
  + - **12 elements: HARQ-ACK delay set = {4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17} for the PDSCH Scheduling delay expression associated to the delay of 2.**
    - **10 elements: HARQ-ACK delay set = {4, 6, 9, 12, 13, 14, 15, 16, 17, 19} for the two PDSCH Scheduling delay expressions associated to the delay of 7.**

Companies are kindly requested to provide their views below:

|  |  |  |
| --- | --- | --- |
| **Company** | **Please state your views on which option you prefer: Alt-C1, Alt-C2, Alt-C3, Alt-C4 or Alt-C5?**  Note: Last RAN1 e-meeting for 17 objectives (Please provide your 1st preference and a 2nd alternative that would be acceptable to you). | **Comments** |
| ZTE | 1st preference: Alt C2  2nd alternative: Alt C1 | For the scheduling delay=7, we do not think too many HARQ delay values less than 12 are needed, since the main motivation of introducing 14-HARQ processes is to improve the peak data rate and more HARQ delay values for providing data rate for invalid subframes is more important.  Moreover, actually, there are only maximum 2 HARQ processes in one round are scheduled for scheduling delay=7, there is no need to define more than 2 HARQ ACK delay values.  Therefore, Alt C2 is the first preference. And Alt C1 is second preference. |
| Ericsson | Alt-C4 or Alt-C2 | Overall Alt-C4, Alt-C2 and Alt-C3 are acceptable. Alt-C4 and Alt-C2 are preferred over Alt-C3 because in an ideal scenario they will make possible to assign the farthest HARQ processes to the nearest PUCCHs, whereas with Alt-C3 that would not be possible (it resembles a special pattern assignment).  Alt-C1 is not preferred because the HARQ-ACK delay set consisting of 10 elements does not contain small delay values. |
| Nokia, NSB | 1st Preference Alt-C2  2nd Preference Alt-C4 | Do not support Alt-C1, No small values for delay 7. |
| Qualcomm | For the 12 elements, we could take Alt C1 or C2.  For the 10 elements, Alt C3 or Alt-C4 (but see notes for a potential compromise) | First of all, apologies for missing one entry in our submission.  We definetely do not support Alt-C1 or C2 for the 12 elements.  Taking a look at the options, we think for the 12 elements almost everyone is on the same page, with minimum differences. We could take the option from C1 or C2, since it seems to be the majority view (also by counting the *votes* for each element).  For the 10 elements, one big issue we see with all the options except for C3 is that there is a big gap between the low delays and the large delays. We could live with something like **{4, 6, 9, 12, 13, 14, 15, 16, 17, 19}.**  We also uploaded in the drafts folder an [XLS](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Inbox/drafts/8.9.2/QC_count.xlsx) with the count (note that the proposed compromise above is not based on the count, but added a value of 9 in between). |
| NordicSemi | Alt-C2, Alt-C3, Alt-C4 | We are fine with any of alternatives except Alt-C1 |
| Lenovo, MotoM | Alt-C2 |  |
| Huawei, HiSilicon | 1st preference: Alt C1  2nd alternative: Alt C2 | For PDSCH scheduling delay 7, the typical HARQ-ACK delay values are 12-19 and there’s very small possibility for small values. Thus, our first preference is Alt-C1. If there’s concern without small values for PDSCH scheduling delay 7, adding 4 and 5 should be just sufficient. |

## 2.2 Usage of DCI fields in Format 6-1A

Background: To indicate the “PDSCH scheduling delay” and “HARQ-ACK delay” there is a need to find out whether some existing DCI fields can be set to zero for the 14 HARQ processes feature as to make use of them for other purposes (e.g., jointly-encoding). The sub-sections below list DCI fields under consideration.

### 2.2.1 “Repetition number” field: 2 bits

#### 2.2.1.1 Down-selection between Opt-2 and Opt-3 for the “Repetition number” field

Background: In RAN1 #106bis-e, the following agreement was reached for the “repetition number” field referring to PDSCH repetitions.

|  |
| --- |
| **Agreement**  **In Rel-17, one option will be downselected from Opt-2 and Opt-3 for the 14 HARQ processes feature the “Repetition number” field in RAN1#107e:**          **Opt-2: 0-bits when the 14 HARQ processes feature is configured (i.e., 2-bits from this field become available for jointly-encoding purposes).**          **Opt-3: 2-bits as in legacy.** |

The table below collects the views that companies have about the usage of the “2-bits: Repetition number” field as in [2-6].

**Table 3: Views on the “Repetition number” field as in [2-6]**

|  |  |
| --- | --- |
| **Company** | **“Repetition number” field: Compendium of views according with [2-6].** |
| **Huawei, HiSilicon [2]** | **Proposal 2: For the 14 HARQ processes feature, Opt-2 is supported for the “Repetition number” field for the 14 HARQ processes feature.** |
| **ZTE [3]** | ***Proposal 2: In Rel-17, for the 14-HARQ processes feature the “Repetition number” field is 0-bits when 14 HARQ processes feature is configured.*** |
| **Nokia, Nokia Shanghai Bell**  **[4]** | **Proposal 2: When the 14 HARQ processes feature, the “Repetition number” field is 2-bits as in legacy.**  **Proposal 3: When the 14 HARQ processes feature is configured and HARQ-ACK bundling flag is set to 1, the “Repetition number” field is ignored by the UE.** |
| **Qualcomm Incorporated [5]** | **Proposal 3: For a UE configured with 14 HARQ processes, the “repetition number field” is 2-bits as in legacy (Option 3)** |
| **Ericsson [6]** | 1. Conclusion: In Rel-17, for the 14 HARQ processes feature the “Repetition number” field is 2-bits as in legacy (i.e., Opt-3). |

According with the submitted contributions, only [2] and [3] propose that the “Repetition number field” will be 0-bits from the moment the 14 HARQ processes feature is configured, whereas the rest of the companies [4-6] highlighted the importance of keeping usable the “Repetition number field” as to be able to act dynamic on changes in the radio environment. Based on the above, potential agreement #3 states that the “Repetition number” field is Opt-3: 2-bits as in legacy.

**Potential Agreement#3:**

**In Rel-17, for the 14 HARQ processes feature the “Repetition number” field is:**

        **~~Opt-2: 0-bits when the 14 HARQ processes feature is configured (i.e., 2-bits from this field become available for jointly-encoding purposes).~~**

        **Opt-3: 2-bits as in legacy.**

Companies are kindly requested to provide their views below:

|  |  |  |
| --- | --- | --- |
| **Company** | Are you ok with Opt-3 as per potential agreement #3?  Note: Last RAN1 e-meeting for 17 objectives (Please recall and account for the technical discussions we already had on this topic in RAN1# 106bis-e). | **Comments** |
| ZTE, Sanechips | No | When 14-HARQ feature is enabled, only one HARQ process requires the repetition is corner case with low probability, especially for the peak data rate case when 14 HARQ processes are scheduled.  Moreover, when Alt1 is configured, keeping 2 bits repetition would cause 4bits DCI size increasing, which would cause obvious DCI performance degradation. it is not worth to support the corner case by sacrificing the precious DCI overhead.  More seriously, when the repetition is needed, it indicates the channel condition become worse. So it is not reasonable to increase the DCI size to further make the PDCCH performance worse.  If we focus on the main use cases of repetition, i.e., more than 1 HARQ process, the current HARQ-ACK delay especially for Alt1 need redefinition.  Therefore, option3 for 14-HARQ processes is not preferred. |
| Ericsson | Ok with Opt-3 | The use-case that requires using the “Repetition number” field cannot be considered as a corner case since bad radio conditions are unpredictable.  About “ *it is not worth to support the corner case by sacrificing the precious DCI overhead* ” I would rather say that 2-bits are not worth losing a legacy functionality that can prevent having to use a re-configuration, specially when in bad radio conditions such a re-configuration may not even go through.  Keeping usable the “Repetition number” field as in legacy as per Opt-3 is essential to face adverse radio conditions that can suddenly occur. |
| Nokia, NSB | Ok with Opt-3 | Maintain functionality for poor radio conditions. |
| Qualcomm | OK with Opt-3 |  |
| NordicSemi | OK with Opt-3 |  |
| Lenovo, MotoM | No | If “Repetition number” is kept, we should also keep the “HARQ-ACK bundling flag” field to indicate the bundling is not enabled, because if we follow the legacy that the repetition is not support for bundling.  *HARQ-ACK bundling flag*=1 *Repetition number* ignore  *HARQ-ACK bundling flag*=0 *Repetition number* used  In that sense, we will use 3 bit, not only 2 bit to support the so-called flexible dynamic scheduling. |
| Huawei, HiSilicon | No | In 14-HARQ processes, there’s little chance that the channel condition get so worse to frequently use repetition. Even some PDSCH fails, there are two to handle it:   * Fall back to CSS, where repetition can be used. If the HARQ processes that CSS cannot support need frequent repetition, then eNB would better to not configure UE with 14 HARQ. * HARQ retransmission, which can handle the unfrequent failure of PDSCH.   Futhermore, if the channel quality is a concern to keep repetition field, the 2-bit DCI size increase would make PDCCH performance worse in poor channel quality. Therefore, it’s not a really consistent reason to keep repetition field. |
| Ericsson | Ok with Opt-3 | To Huawei: As we discussed already in RAN1#106bis-e, the “Fall-back to CSS” is not a viable solution because it is unpredictable which HARQ process # will be affected by the adverse radio conditions. The HARQ retransmission can perhaps be seen as a work-around solution, nonetheless the “Repetition number” is a legacy functionality already in place tailored made to face the bad radio condition scenarios we have been discussing.  Finally, about the comment “*the 2-bit DCI size increase would make PDCCH performance worse in poor channel quality*”, we have made some calculations assuming that the current DCI size is approximately 38 bits long, from which we found that the coverage impact is much less than 1 dB, indeed the obtained results was: 10 log (38/40) = ⁓ -0.22dB. Yet, if we account for a 16 bit CRC the difference is even smaller ~ -0.16 dB. |

#### 2.2.1.2 Usability of the “Repetition number” field if remains as in legacy

If the “Repetition number” were to remain 2-bits as in legacy, it is important to have a common understanding on how it will be used while the 14 HARQ processes feature is configured, the following observations and proposals in relation with it can be found in [4-6]:

**Table 4: Views on the usability of “Repetition number” field as in [4-6]**

|  |  |
| --- | --- |
| **Company** | **Usability of the “Repetition number” field: Compendium of views as in [4-6].** |
| **Nokia, Nokia Shanghai Bell**  **[4]** | **“If proposal 2 is agreed, then the UE should not be expected to use the repetition field when HARQ-ACK bundling flag is set to 1. Since whenever the network is attempting the attain the highest data rates through the use of 14-HARQ processes with HARQ-ACK bundling, it can be assumed that the channel conditions are good.”**  **Proposal 3: When the 14 HARQ processes feature is configured and HARQ-ACK bundling flag is set to 1, the “Repetition number” field is ignored by the UE.** |
| **Qualcomm Incorporated [5]** | **“the UE could be configured simultaneously with PDSCH repetition and 14 HARQ processes, although the operation of 14 HARQ processes simultaneously with PDSCH repetition may not be optimized. It should also be supported to dynamically switch (by scheduling) between 14 HARQ processes scheduling (with PDSCH scheduling delay and HARQ-ACK bundling), 10 HARQ processes (with HARQ bundling), and Rel-13 (no bundling, support of repetitions)”** |
| **Ericsson [6]** | Observation 14: In R1-2110414, it was proven that the PDSCH scheduling and HARQ-ACK delay expressions won’t require any modification. The usage of the “Repetition number” is connected to the 1 HARQ process case in adverse radio conditions. |

Based on the views in Table 4, three alternatives are subject to down-selection as per the potential agreement#4:

**Potential Agreement#4:**

**To down-select one of the following alternatives:**

* **Opt-3\_Alt-1: Conclusion: In Rel-17 for the 14 HARQ processes feature, PDSCH repetitions are only usable when there is only one HARQ process in use.**
* **Opt-3\_Alt-2: When the 14 HARQ processes feature is configured and HARQ-ACK bundling flag is set to 1, the “Repetition number” field is ignored by the UE.**
* **Opt-3\_Alt-3: The usage of PDSCH repetitions is left up to the eNodeB to handle.**

Companies are kindly requested to provide their views below:

|  |  |  |
| --- | --- | --- |
| **Company** | **Please state your views on which option you prefer: Opt-3\_Alt-1, Opt-3\_Alt-2 or Opt-3\_Alt-3?**  Note: Last RAN1 e-meeting for 17 objectives (Please provide your 1st preference and a 2nd option that would be acceptable to you). | **Comments** |
| ZTE, Sanechips |  | No need to discuss this. The discussion is based on the outcome of Potential Agreement#3: |
| Ericsson | Opt-3\_Alt-3 or  Opt-3\_Alt-1/Opt-3\_Alt-2 | We slightly prefer Opt-3\_Alt-3 over Opt-3\_Alt-1/Opt-3\_Alt-2, although we do not have a strong preference (i.e., The most important thing is to have all the same understanding). |
| Nokia, NSB | Alt-2 or Alt-1 | Alt-2 strikes us a reasonable compromise, that by default should include Alt-1 (as a subset of Alt-2), and avoids the unrealistic scenario of operating bundling with repetition (Alt-3). |
| Qualcomm | Alt-2 | In our understanding, Alt-2 is the current behavior (adding the corresponding RRC parameter to the followign condition): |
| Lenovo,MotoM |  | It depends on the Potential Agreement#3.  I am not sure what the difference between alt 1 and alt 2. Both say if **HARQ-ACK bundling flag is set to 1, the “Repetition number” field is ignored by the UE.** |
| Huawei, HiSilicon |  | The discussion depends on decision of potential agreement #3. |

### 2.2.2 “HARQ-ACK delay” field: 3 bits

Background: In Rel-17, the HARQ-ACK delay (either based on Alt-1 or Alt-2e) will be indicated together with the PDSCH Scheduling delay through joint-encoding using a single DCI field. Thus, it is under discussion whether this legacy DCI field will be set to 0-bits depending on the status of the HARQ-ACK bundling flag, or if it will set to 0-bits from the moment the 14 HARQ process feature is configured. The table below collects the views that companies have about the usage of the “3-bits: HARQ-ACK delay” field as in [2-6].

**Table 4: Views on the “HARQ-ACK delay” field as in [2-6]**

|  |  |
| --- | --- |
| **Company** | **“HARQ-ACK delay” field: Compendium of views according with [2-6].** |
| **Huawei, HiSilicon [2]** | **Proposal 3: For the 14 HARQ processes feature the “HARQ-ACK delay” field is 0-bits when the 14 HARQ processes feature is configured (i.e., 3-bits from this field become available e.g., for jointly-encoding purposes).** |
| **ZTE [3]** | ***Proposal 3: In Rel-17, for the 14-HARQ processes feature the “HARQ-ACK delay” field is 0-bits when 14 HARQ processes feature is configured.*** |
| **Ericsson [6]** | Observation 15: In the case of the “HARQ-ACK delay” field, Opt-1 nor Opt-2 incur in any drawback of losing any legacy functionality, especially because in Rel-17 this field is enhanced by the HARQ-ACK delays given by either Alt-1 or Alt-2e which are provided through a new DCI field that jointly-encodes the PDSCH scheduling delay and HARQ-ACK delay.  Proposal 3: In Rel-17, for the 14 HARQ processes feature the “HARQ-ACK delay” field is: Opt-2: 0-bits when the 14 HARQ processes feature is configured (i.e., 3-bits from this field become available for joint-encoding purposes). |

Based on the above, potential agreement #5 states that the “HARQ-ACK delay” field is Opt-2: 0-bits when the 14 HARQ processes feature is configured (i.e., 3-bits from this field become available for jointly-encoding purposes).

**Potential Agreement#5:**

**In Rel-17, for the 14 HARQ processes feature the “HARQ-ACK delay” field is:**

~~~~ **~~Opt-1: 0-bits when the “HARQ-ACK bundling flag” is set to 1 (i.e., 3-bits from this field become available for jointly-encoding purposes)~~**

         **Opt-2: 0-bits when the 14 HARQ processes feature is configured (i.e., 3-bits from this field become available for jointly-encoding purposes).**

Companies are kindly requested to provide their views below:

|  |  |  |
| --- | --- | --- |
| **Company** | Are you ok with Opt-2 as per potential agreement #5? | **Comments** |
| ZTE | Yes |  |
| Ericsson | OK |  |
| Nokia, NSB | OK |  |
| Qualcomm | OK |  |
| NordicSemi | OK |  |
| Lenovo, MotoM | OK |  |
| Huawei, HiSilicon | OK |  |

# 3 References

1. [RP-201306](http://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_88e/Docs/RP-201306.zip), WID: Additional enhancements for NB-IoT and LTE-MTC, RAN #88e, Electronic Meeting, June 29th-3rd, 2020.
2. [R1-2110858](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2110858.zip), “Support of 14-HARQ processes in DL for HD-FDD MTC UEs,” Huawei, HiSilicon, RAN1 #107-e, November 11th – 19th, 2021.
3. [R1-2111071](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111071.zip), “Remaining issues on 14-HARQ processes in DL for eMTC,” ZTE, RAN1 #107-e, November 11th – 19th, 2021.
4. [R1-2111134](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111134.zip), “Support of 14-HARQ processes in DL for eMTC,” Nokia, Nokia Shanghai Bell, RAN1 #107-e, November 11th – 19th, 2021.
5. [R1-2111450](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2111450.zip), “Support of 14 HARQ processes and scheduling delay,” Qualcomm Incorporated, RAN1 #107-e, November 11th – 19th, 2021.
6. [R1-2112362](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_107-e/Docs/R1-2112362.zip), “Support of 14 HARQ processes in DL in LTE-MTC,” Ericsson, RAN1 #107-e, November 11th – 19th, 2021.
7. Session notes for 8.9 (Rel-17 enhancements for NB-IoT and LTE-MTC), Ad-hoc chair (Samsung), 3GPP TSG RAN WG1 Meeting #102-e, e-Meeting, August 17th – 28th, 2020.
8. Session notes for 8.9 (Rel-17 enhancements for NB-IoT and LTE-MTC), Ad-hoc chair (Samsung), 3GPP TSG RAN WG1 Meeting #103-e, e-Meeting, October 26th – November 13th, 2020.
9. Session notes for 8.9 (Rel-17 enhancements for NB-IoT and LTE-MTC), Ad-hoc chair (Samsung), 3GPP TSG RAN WG1 Meeting #104-e, e-Meeting, January 25th – February 5th, 2021.
10. Session notes for 8.9 (Rel-17 enhancements for NB-IoT and LTE-MTC), Ad-hoc chair (Samsung), 3GPP TSG RAN WG1 Meeting #104-bis-e, e-Meeting, April 12th – 20th, 2021.
11. Session notes for 8.9 (Rel-17 enhancements for NB-IoT and LTE-MTC), Ad-hoc chair (Samsung), 3GPP TSG RAN WG1 Meeting #105-e, e-Meeting, May 10th – 27th, 2021.
12. Session notes for 8.9 (Rel-17 enhancements for NB-IoT and LTE-MTC), Ad-hoc chair (Samsung), 3GPP TSG RAN WG1 Meeting #106-e, e-Meeting, August 16th – 27th, 2021.
13. Session notes for 8.9 (Rel-17 enhancements for NB-IoT and LTE-MTC), Ad-hoc chair (Samsung), 3GPP TSG RAN WG1 Meeting #106bis-e, e-Meeting, October 11th – 19th, 2021.

# Annex 1

## A1.1 List of agreements from RAN1 #102-e:

**Agreement**

Introduce a new RRC configuration parameter to enable 14 HARQ processes.

**Agreement**

For a UE configured with 14 HARQ processes, a PDSCH scheduling delay of 2 BL/CE DL subframes and 7 [FFS subframes type(s)] is supported at least in the PUCCH non-repetition case:

* FFS details of signaling.
* FFS other delay values to account for the presence of non-BL/CE subframes in the PUCCH non-repetition case.
* FFS if the 14 HARQ processes feature is supported in PUCCH repetition case.

**Working Assumption**

Introduce a new optional UE capability to support 14 HARQ processes

## A1.2 List of agreements from RAN1 #103-e:

**Agreement**

The following working assumption is confirmed

Introduce a new optional UE capability to support 14 HARQ processes

**Agreement**

The design of the 14 HARQ processes feature accounts for the presence of non-BL/CE UL and DL subframes in the PUCCH non-repetition case.

* FFS: PDSCH scheduling delays
* FFS: HARQ-ACK delays
* FFS: Configurable/dynamic set of PDSCH delays/HARQ-ACK delays

**For future meetings:**

Companies to further study on the impact of measurement gaps on the 14 HARQ processes feature.

**Agreement**

For the support of 14 HARQ processes, the solution to assign PDSCH scheduling delays should be able to minimize unnecessary waste of subframes derived from the presence of non-BL/CE DL subframes and non-BL/CE UL subframes.

* The following solutions will be further investigated:
  + The indication of subframe types for the PDSCH scheduling delay of 7 are:
    - 1 BL/CE DL subframe + 1 subframe + 3 [BL/CE UL subframes] + 1 subframe + 1 BL/CE DL subframe.
    - 1 subframe + 3 [BL/CE UL subframes] + 1 subframe + 2 BL/CE DL subframes.
  + Configurable delays including other values than 2 and 7.
* Other solutions are not precluded.

**Agreement**

For the support of 14 HARQ processes, the solution to assign HARQ-ACK delays should aim to maximize the number of HARQ processes that can be scheduled in presence of non-BL/CE DL subframes and non-BL/CE UL subframes.

* Different percentages of presence of non-BL/CE subframes can be analyzed as to represent typical scenarios and determine which HARQ-ACK delays should be included.

## A1.3 List of agreements from RAN1 #104-e:

**Agreement**

The PDSCH scheduling delay for the PUCCH non-repetition case (i.e., PUCCH repetitions = 1):

* 2 BL/CE DL subframes.
* The PDSCH scheduling delay of 7 is expressed as:
  + 1 BL/CE DL subframe + 1 subframe + [3 subframes] + 1 subframe + 1 BL/CE DL subframe.
  + 1 subframe + [3 subframes] + 1 subframe + 2 BL/CE DL subframes.

**Agreement**

For the 14 HARQ processes feature, when PUCCH is used with 1 repetition and there is presence of non-BL/CE UL subframes (i.e., invalid UL subframes):

* The term surrounded by brackets in Solution 1 is resolved as 3 BL/CE UL subframes.

## A1.4 List of agreements from RAN1 #104-bis-e:

**Agreement**

In Rel-17, for the 14 HARQ processes feature, PUCCH repetition is not supported with HARQ-ACK bundling.

**Conclusion**

In Rel-17, the 14 HARQ processes feature is not supported when the multi-TB grant feature is enabled.

**R1-2103860** Feature Lead Summary [104b-e-LTE-Rel17\_NB\_IoT\_eMTC-02]: 2nd check point Moderator (Ericsson)

**Agreement**

In Rel-17, for the 14 HARQ process feature the HARQ-ACK delay solution will be down-selected in RAN1#105-e from:

* Alt-1: The HARQ-ACK delay is determined through an expression consisting of different subframe types (Using a similar principle as the PDSCH scheduling delay).
  + FFS: The expression consisting of different subframe types.
  + FFS: Signaling Details.
* Alt-2: The HARQ-ACK delay is determined following the legacy approach. That is, the “HARQ-ACK delay” is kept expressed in terms of “absolute subframes”.
  + FFS: The percentage of presence of non-BL/CE DL subframes and non-BL/CE UL subframes to be handled.
  + FFS: HARQ-ACK delay values and length of the HARQ-ACK delay set.
  + FFS: Signaling Details.

The following aspects will be considered towards the down-selection of one of the two alternatives (i.e., Alt-1 or Alt-2) for the HARQ-ACK delay solution:

1. Total number of bits required in DCI
2. Scenarios that can be handled, including:

(a) different numbers of scheduled HARQ processes per burst (including dynamically switching between more than 10 HARQ processes and 10 or less HARQ processes)

(b) different % of invalid subframes for both 10 and 40 SF long bitmaps

1. Robustness against loss of DCIs
2. Flexibility
3. RRC signaling overhead

## A1.5 List of agreements from RAN1 #105-e:

**Agreement**

In Rel-17, for the 14 HARQ process feature the HARQ-ACK delay solution will be supported with multiple solutions: Alt-1 for full flexibility and Alt-2e for support of legacy delay

Alt-1: The HARQ-ACK delay is determined through an expression consisting of different subframe types (Using a similar principle as the PDSCH scheduling delay).

* + Without using more than 6 bits
  + FFS: How to minimize the overhead by using joint encoding

Alt-2e: The HARQ-ACK delay is determined following the legacy approach. That is, the “HARQ-ACK delay” is kept expressed in terms of “absolute subframes”.

* + The HARQ-ACK delay values and the length of the HARQ-ACK delay set will be based on
    - Alt-2e: “3 bits (same as legacy)”
    - FFS: Whether HARQ delay set is to use range1 or range2

RRC signaling will be used to configure between Alt-1 and Alt-2e

FFS: Signaling details

FFS: Joint encoding

**Working Assumption**

The PDSCH scheduling delay and HARQ-ACK delay are jointly encoded in a single DCI field:

* The field uses no more than 7 bits if Alt-1 is configured.
* The field is 5 bits if Alt-2e is configured.
* FFS: Details of the joint encoding.
* FFS: Legacy DCI fields that might be re-purposed for the jointly encoded solution of Alt-1 and Alt-2e respectively.

Note: Alt-1 expresses the HARQ-ACK delay as: (y) BL/CE DL subframe + 1 subframe + (z) BL/CE UL subframes, where y = {0, 1, 2, … 11} and z = {1, 2, 3}.

**Conclusion:**

In Rel-17, for the 14 HARQ processes feature:

When the HARQ-ACK delay is configured to use Alt-1 “PUCCH using Repetition = 1 is postponed”, whereas when the HARQ-ACK delay is configured to use Alt-2e “PUCCH using Repetition = 1 is not postponed (legacy behavior)”.

**Agreement**

In Rel-17, the 14 HARQ processes feature is applicable for HD-FDD Cat M1 UEs in CE Mode A only.

**For discussion in future meetings:**

Whether 14 HARQ processes feature can be enabled for PDSCH repetition case

## A1.6 List of agreements from RAN1 #106-e:

Agreement

Confirm the below Working Assumption for Alt-2e with following updates

The PDSCH scheduling delay and HARQ-ACK delay are jointly encoded in a single DCI field:

* The field is 5 bits if Alt-2e is configured.
* FFS: Details of the joint encoding.
* FFS: Legacy DCI fields that might be set to zero bits in length for the jointly encoded solution Alt-2e.

For Alt-1, it will be separate discussion based existing working assumption

Agreement

Confirm the below Working Assumption for Alt-1 with following updates

The PDSCH scheduling delay and HARQ-ACK delay are jointly encoded in a single DCI field:

* The field is no more than 7 bits if Alt-1 is configured.
* FFS: Details of the joint encoding.
* FFS: Legacy DCI fields that might be set to zero bits in length for the jointly encoded solution Alt-1.

Note: Alt-1 expresses the HARQ-ACK delay as: (y) BL/CE DL subframe + 1 subframe + (z) BL/CE UL subframes, where y = {0, 1, 2, … 11} and z = {1, 2, 3}.

Agreement

For the PDSCH scheduling delay and HARQ-ACK delay jointly encoded in a single DCI field:

* The DCI field uses 7 bits if Alt-1 is configured.

Conclusion

How to implement/describe the states, e.g., table, resulting from the joint encoding solution of Alt-1 is left up to the Editor, based on the agreements for the PDSCH scheduling delay, HARQ-ACK delay and the WA confirmed for Alt-1.

## A1.7 List of agreements from RAN1 #106bis-e:

**Working Assumption**

**For the joint encoding** **of “PDSCH Scheduling delay” and “HARQ-ACK delay” when Alt-2e is configured, the HARQ-ACK delay set has a size of:**

* **Alt-C:**
  + - **12 elements: HARQ-ACK delay set = {a, b, c, d, e, f, g, h, i, j, k, l} for the PDSCH Scheduling delay expression associated to the delay of 2.**
    - **10 elements: HARQ-ACK delay set = {o, p, q, r, s, t, u, v, x, w} for the two PDSCH Scheduling delay expressions associated to the delay of 7.**
      * **FFS: The values of {a, b, c, d, e, f, g, h, i, j, k, l}, {o, p, q, r, s, t, u, v, x, w} where some of these elements may share the same value.**

**Conclusion:**

**How to implement/describe the states, e.g., table, resulting from the joint encoding solution of Alt-2e is left up to the Editor, based on the agreements for the PDSCH scheduling delay, HARQ-ACK delay and the WA confirmed for Alt-2e.**

**Agreement**

**The Rel-17 14 HARQ processes feature only applies to User Specific Search Space (USS)**

**Agreement**

**In Rel-17, for the 14 HARQ processes feature the “HARQ-ACK process number” field uses 4-bits.**

* **The mapping associated to the 4-bits of this field is updated to include the newly added HARQ processes (i.e., 11th, 12th, 13th, and 14th HARQ processes).**

**Agreement**

**In Rel-17, for the 14 HARQ processes feature the following updates on the technical specification are to be performed.**

* **The maximum number of received PDSCH receptions pending HARQ-ACK is set to W = 12 (in Sect. 7.3.1 of TS 36.213) when the UE is configured with 14 HARQ processes.**

**Agreement**

**In Rel-17, one option will be downselected from Opt-2 and Opt-3 for the 14 HARQ processes feature the “Repetition number” field in RAN1#107e:**

        **Opt-2: 0-bits when the 14 HARQ processes feature is configured (i.e., 2-bits from this field become available for jointly-encoding purposes).**

        **Opt-3: 2-bits as in legacy.**