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

e-Meeting, October 11th – 19th, 2021

Agenda Item: 8.9.2

Source: Moderator (Ericsson)

Title: Feature Lead Summary [106bis-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:

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| --- |
| * 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], and RAN1 #106bis-e [12].

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

## 2.2 “PDSCH scheduling delay” and “HARQ-ACK delay” using Alt-2e

### 2.2.1 HARQ-ACK delay set(s) for Alt-2e

Background: In RAN1 #106-e, the Working Assumption (WA) for Alt-2 was confirmed with the following updates:

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| **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** |

Once the WA for the joint encoding of Alt-2e has been confirmed, RAN1 needs to decide what will be the size of the HARQ-ACK delay set and the delay values it contains. In relation with it, Table 1 summarizes the observations and proposals as in [2-6]:

**Table 1: HARQ-ACK delay set(s) for Alt-2e according with [2-4] and [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 delays 2 and 7 should be different if Alt-2e is configured.****Proposal 2: The set of HARQ-ACK delay values associated with PDSCH scheduling delay 2 is from 4 to 17, and the set of HARQ-ACK delay values associated with PDSCH scheduling delay 7 is from 12 to 19 if Alt-2e is configured.** |
| **Nokia, Nokia Shanghai Bell [3]** | **Proposal 1: For the joint encoding of the “PDSCH Scheduling delay” and the “HARQ-ACK delay” when Alt-2e is configured, the HARQ-ACK delay set has a size of:*** + **14 elements: HARQ-ACK delay set = {a, b, c, d, e, f, g, h, i, j, k, l, m, n} for the PDSCH Scheduling delay expression associated to the delay of 2.**
	+ **9 elements: HARQ-ACK delay set = {****o, p, q, r, s, t, u, v, 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, m, n, o, p, q, r, s, t, u, v, w}, where some of these parameters may share the same value.**
 |
| **ZTE [4]** | ***Observation 1: The minimum value of HARQ-ACK delay is 4 when PDSCH scheduling delay is 2 and the minimum value of HARQ-ACK delay is 12 when PDSCH scheduling delay is 7.******Observation 2: If percentage of invalid subframe is 10%, 20% and 30%, the maximum value of HARQ-ACK delay is increased by the number of invaild subframes in two frames when the PDSCH scheduling delay is 7***.***Observation 3: When the PDSCH scheduling delay is 2, the maximum value of HARQ-ACK delay is increased by the number of invalid subframe(s) in one frame if percentage of invalid subframe is 10% and 20% and the maximum value of HARQ-ACK delay is increased by the number of invalid subframes in two frames if percentage of invalid subframe is 30%.******Observation 4: If the percentage of invalid subframe is less than or equal to 30%, the maximum value of HARQ-ACK delay is 17 when PDSCH scheduling is 2 and the maximum value of HARQ-ACK delay is 19 when PDSCH scheduling is 7.*** ***Observation 5: The value of supported HARQ-ACK delay is affected by bundling pattern and the position of invalid subframes. Continuous HARQ-ACK delay values can meet the requirements of more scenarios.******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:**** ***14 elements: HARQ-ACK delay set = {a, b, c, d, e, f, g, h, i, j, k, l, m, n} for the PDSCH Scheduling delay expression associated to the delay of 2.***
* ***9 elements: HARQ-ACK delay set = {a, b, c, d, e, f, o, p, q } for the two PDSCH Scheduling delay expressions associated to the delay of 7.***

***Wherein a=12, b=13, c=14, d=15, e=16, f=17, o=18, p=19, q=20 or q=g , g=4, h=5, i=6, j=7, k=8, l=9, m=10, n=11.*** |
| **Ericsson [6]** | 1. For the joint encoding of “PDSCH Scheduling delay” and “HARQ-ACK delay” when Alt-2e is configured, down-select whether the HARQ-ACK delay set is based on Opt-1 or Opt-2:
* Opt-1:
	+ 10 elements: HARQ-ACK delay set = {a, b, c, d, e, f, g, h, i, j} equally applicable for each of the three PDSCH Scheduling delay expressions.
* Opt-2:
	+ 10 elements: HARQ-ACK delay set = {a, b, c, d, e, f, g, h, i, j} for the PDSCH Scheduling delay expression associated to the delay of 2.
	+ 11 elements: HARQ-ACK delay set = {a, b, c, d, e, f, g, h, i, j, k} for the two PDSCH Scheduling delay expressions associated to the delay of 7.
1. The HARQ-ACK delay set is based on range1 preserving all the legacy delays i.e., HARQ-ACK delay = {4, 5, 7, 9, 11, 13, 15, 17, i, j/k}, along with the delay values in the tail-end (i.e., {i, j/k}) selected as follows:
	* + “j/k” is continued using the legacy 2-step size e.g., j = 19/k=21, this would make possible handling ⁓ 35%/⁓42% presence of evenly distributed non-BL/CE DL subframes.
		+ “i” is arbitrarily chosen as i = 6, this would make possible in ideal scenarios bundling the farthest HARQ processes (i.e., #10, #11, #12, #13, #0, … #5) to the closest “PUCCH#0 and PUCCH#1” and closest HARQ processes (#6, #7, #8, #9) to “PUCCH#2”.

That is:* PUCCH#0 would be able to bundle HARQ processes {#12 or #10, #0, #2, #4}.
* PUCCH#1 would be able to bundle HARQ processes {#13 or #11, #1, #3, #5}.
* PUCCH#2 would be able to bundle HARQ processes {#6, #7, #8, #9}
1. The HARQ-ACK delay set based on range 1 as defined in proposal 2 allows to handle ideal scenarios in a suitable manner (farthest HARQ processes to closest PUCCHs and vice versa) and equips Alt-2e with delays that handle more than just a few invalid subframes (e.g., up to ⁓ 35%/⁓42% evenly distributed non-BL/CE DL subframes).
 |

Table 2 presents a one-on-one comparison of the proposed solutions for the HARQ-ACK delay set(s) for Alt-2e as in [2-4] and [6].

**Table 2**: **Comparison of the HARQ-ACK delay set(s) for Alt-2e according with [2-4] and [6].**

|  |  |
| --- | --- |
| **General Description** | **Design Criteria: From RAN1# 105-e it was left as “*FFS: Whether HARQ delay set is to use range1 or range2*”.****Range 1: {4, 5, 7, 9, 11, 13, 15, 17}****Range 2: {****4, 5, 6, 7, 8, 9, 10, 11}** |
| **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:** |
| **Opt-A: HARQ-ACK delay sets as in [2]:** **14 elements: HARQ-ACK delay set = {4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17} for the PDSCH Scheduling delay expression associated to the delay of 2.****8 elements: HARQ-ACK delay set = {12, 13, 14, 15, 16, 17, 18, 19} for the two PDSCH Scheduling delay expressions associated to the delay of 7.** | **Opt-B: HARQ-ACK delay sets as in [3]:** **14 elements: HARQ-ACK delay set = {a, b, c, d, e, f, g, h, i, j, k, l, m, n} for the PDSCH Scheduling delay expression associated to the delay of 2.****9 elements: HARQ-ACK delay set = {o, p, q, r, s, t, u, v, 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, m, n, o, p, q, r, s, t, u, v, w}, where some of these parameters may share the same value**
 | **Opt-C: HARQ-ACK delay sets as in [4]:** **14 elements: HARQ-ACK delay set = {12, 13, 14, 15, 16, 17, 4, 5, 6, 7, 8, 9, 10, 11} for the PDSCH Scheduling delay expression associated to the delay of 2.****9 elements: HARQ-ACK delay set = {12, 13, 14, 15, 16, 17, 18, 19, 20 or 4} for the two PDSCH Scheduling delay expressions associated to the delay of 7.** | **Opt-D: HARQ-ACK delay sets as in [6]:** **10 elements: HARQ-ACK delay set = {4, 5, 6, 7, 9, 11, 13, 15, 17, 19} for the PDSCH Scheduling delay expression associated to the delay of 2.****10 or [11] elements: HARQ-ACK delay set = {4, 5, 6, 7, 9, 11, 13, 15, 17, 19 [, 21]} for the two PDSCH Scheduling delay expressions associated to the delay of 7.**  |
| **Pros** | * Different than Opt-B and Opt-C which utilize the same framework, Opt-A fully utilizes the legacy range2 for the PDSCH scheduling delay expression associated to the delay of 2. However, for the PDSCH scheduling delay expressions associated to the delay of 7 no range 1 nor range2 are fully utilized.
 | * Fully exploits the 32 states available with 5-bits.
 | * Fully exploits the 32 states available with 5-bits.
 | * The HARQ-ACK delay set fully utilizes the legacy range1 for all the PDSCH scheduling delay expressions associated to the delays of 2 and 7.
* The variant using 10 elements, provides a balanced HARQ-ACK delay set size (i.e., same size and same delay values) for all the PDSCH scheduling delay expressions.
* The variant using [11] elements, fully exploits the 32 states available with 5-bits.
 |
| **Cons** | **Cons in common:*** Unbalanced HARQ-ACK delay set size.

The design is short delay heavy. That is, the size of the HARQ-ACK delay set is longer for the PDSCH scheduling delay expression associated to the delay of 2, which may not make possible to handle certain scenarios for the two PDSCH scheduling delay expressions associated to the delay of 7.* For Opt-A: HARQ-ACK delay sets as in [2], the HARQ-ACK delay set has 75% more delays for the PDSCH scheduling delay expression of 2 than for the expressions of 7.
* For Opt-B: HARQ-ACK delay sets as in [3], the HARQ-ACK delay set has 56% more delays for the PDSCH scheduling delay expression of 2 than for the expressions of 7.
* For Opt-B: HARQ-ACK delay sets as in [4], the HARQ-ACK delay set has 56% more delays for the PDSCH scheduling delay expression of 2 than for the expressions of 7.
 | * The variant using 10 elements, only exploits 30 states out of the 32 states available with 5-bits.
 |
| * Only exploits 30 states out of the 32 states available with 5-bits.
* Only for the PDSCH scheduling delay expression associated to the delay of 2, the HARQ-ACK delay set fully utilizes one of the legacy ranges (in this case range2). That is the HARQ-ACK delay set for the PDSCH scheduling delay expressions associated to the delay of 7 has just three delay values from range 1.
 | * The actual delay values in the HARQ-ACK delay have not been provided yet, and without them is not possible to have the full picture of the solution as to know which are the scenarios that can and cannot be addressed with this proposal.
 | * None of the HARQ-ACK delay sets fully utilizes one of the legacy ranges (i.e., no range1 nor range2).
 |

The following potential agreement is intended to summarize all the proposed solutions in [2-4] and [6] as to select only one.

**Potential Agreement#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:**

* **Alt-A:**
	+ **Alt-A1:**
		- **14 elements: HARQ-ACK delay set = {4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17} for the PDSCH Scheduling delay expression associated to the delay of 2.**
		- **8 elements: HARQ-ACK delay set = {12, 13, 14, 15, 16, 17, 18, 19} for the two PDSCH Scheduling delay expressions associated to the delay of 7.**
	+ **Alt-A2:**
		- **14 elements: HARQ-ACK delay set = {a, b, c, d, e, f, g, h, i, j, k, l, m, n} for the PDSCH Scheduling delay expression associated to the delay of 2.**
		- **9 elements: HARQ-ACK delay set = {o, p, q, r, s, t, u, v, 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, m, n, o, p, q, r, s, t, u, v, w}, where some of these parameters may share the same value**
	+ **Alt-A3:**
		- **14 elements: HARQ-ACK delay set = {12, 13, 14, 15, 16, 17, 4, 5, 6, 7, 8, 9, 10, 11} for the PDSCH Scheduling delay expression associated to the delay of 2.**
		- **8 elements: HARQ-ACK delay set = {12, 13, 14, 15, 16, 17, 18, 19, 20 or 4} for the two PDSCH Scheduling delay expressions associated to the delay of 7.**
* **Alt-B:**
	+ **Alt-B1:**
		- **10 elements: HARQ-ACK delay set = {4, 5, 6, 7, 9, 11, 13, 15, 17, 19} for the PDSCH Scheduling delay expression associated to the delay of 2.**
		- **10 elements: HARQ-ACK delay set = {4, 5, 6, 7, 9, 11, 13, 15, 17, 19} for the two PDSCH Scheduling delay expressions associated to the delay of 7.**
	+ **Alt-B2**
		- **10 elements: HARQ-ACK delay set = {4, 5, 6, 7, 9, 11, 13, 15, 17, 19} for the PDSCH Scheduling delay expression associated to the delay of 2.**
		- **11 elements: HARQ-ACK delay set = {4, 5, 6, 7, 9, 11, 13, 15, 17, 19, 21]} for the two PDSCH Scheduling delay expressions associated to the delay of 7.**

**Note 1: The highlighted delay values in the alternatives above correspond to either range1 = {4, 5, 7, 9, 11, 13, 15, 17} or range2 = {4, 5, 6, 7, 8, 9, 10, 11}.**

**Note 2: Only one alternative under the umbrella of either Alt-A or Alt-B is to be selected.**

Companies are kindly requested to provide their views below:

|  |  |  |
| --- | --- | --- |
| **Company** | **Please state your views and technical reasons on which alterntive you prefer under the umbrella of Alt-A or Alt-B** | **Comments**  |
| Lenovo, MotoM | Alt-A | Bacause there are higher probablity of the PDSCH schedulding delay of 2 in the current framework of DL-UL transmission cycle, so we should give more HARQ-ACK delay flexibitlity for PDSCH scheduling delay of 2 to handle to possible invalid subframe percentage. |
| Nokia, NSB | Alt-A | Same reason as Lenovo. We have no strong view on the actual delay values, just that the range of delays for 2 should be longer than the range for 7.  |
| ZTE, Sanechips | Alt-A | A similar view with Lenovo.Additionally, in the legacy design, scheduling delay 7 even does not exist , there is no need to keep the same with legacy and no back-compatible issue is observed. That is to say, keeping the all the legacy values is not needed for the scheduling delay 7.Also, Alt-A support more flexible bundling pattern and more flexible invalid subframe location, since the HARQ-delay value is almost continuous.Therefore, Alt-A is preferred.It is noted that for Alt-A3, the number of elements for scheduling 7 is 9, instead of 8. |
| Qualcomm | Alt-B | One major issue with the Alt-A is that the delay of 7 does not allow for small HARQ-ACK delays. In case the last PDSCH of a burst of data is scheduled with 7, the UE will need to wait too long for transmitting the HARQ-ACK.Maybe we could have some middle ground, and allow 12 elements for scheduling delay of 2, and 10 for 7? |
| Huawei, HiSilicon | Alt-A | Similar view with Lenovo. The delay of 7 is only used when the MPDCCH is followed immediately by PUCCH, while delay of 2 is used for other cases, therefore, the PDSCH scheduling delay of 2 should have more HARQ-ACK delay flexiblity than the PDSCH scheduling delay of 7.As we evaluated, the HARQ-ACK delay set {4-17} for delay 2 and the set {12-19} for delay 7 have covered most cases when the percentage of reserved subframes is not large. |
| Ericsson | See comment | To us Alt-A seems to be designed having in mind that 14 HARQ processes are always in use over time. Alt-A will leave unaddressed certain scenarios, for example the one brought up by Qualcomm (i.e., last PDSCH of a burst of data is scheduled with 7) and also I think that if e.g., in the second scheduling cycle the number of HARQ processes in use is less or equal than 8 HARQ processes but larger or equal than 1 HARQ process, then the HARQ-ACK delay set proposed to be used for the delay of 7 won’t have the required delay values to handle those scenarios.Therefore, Qualcomm’s “middle ground” proposal seems to be a reasonable solution that is in-between Alt-A and Alt-B. |

### 2.2.2 Implementation of Alt-2 into the technical specifications

In RAN1# 106-e, the implementation of the states resulting from the 7-bit joint-encoding solution of the “PDSCH Scheduling delay” and “HARQ-ACK delay” when Alt-1 is configured was left up to the Editor of the technical specifications through the following 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.*”

In a similar manner, the implementation of the states resulting from the 5-bit joint-encoding solution of “PDSCH Scheduling delay” and “HARQ-ACK delay” when Alt-2e is configured, is proposed to be left up to the Editor:

**Potential Conclusion#1:**

**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.**

Companies are kindly requested to provide their views below:

|  |  |  |
| --- | --- | --- |
| **Company** | **Please indicate whether you are Ok or not with Potential Conclusion#1?** | **Comments**  |
| Lenovo, MotoM | OK | Hope we can have similar implement/texts for Alt-1 and Alt-2e as discussed in last meeting. |
| Nokia, NSB | OK |  |
| ZTE, Sanechips | OK |  |
| Qualcomm | OK |  |
| Huawei, HiSilicon | OK |  |
| Ericsson | OK |  |

## 2.3 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), which will help to do not have to drastically increase the DCI size. The sub-sections below list each of the DCI fields mentioned in [2-6].

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

Background: In RAN1 #105-e, the following was noted in relation with the PDSCH repetition associated to the 2-bits “repetition number” field:

|  |
| --- |
| **For discussion in future meetings:**Whether 14 HARQ processes feature can be enabled for PDSCH repetition case |

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 3: For the 14 HARQ processes feature the “Repetition number” field is 0-bits when the 14 HARQ processes feature is configured (i.e., 2-bits from this field become available e.g., for jointly-encoding purposes).** |
| **Nokia [3]** | **Proposal 3: In Rel-17, for the 14 HARQ processes feature the “Repetition number” field is:*** + - **0-bits when the 14 HARQ processes feature is configured (i.e., 2-bits from this field become available e.g., for jointly-encoding purposes).**
 |
| **ZTE [4]** | ***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.*** |
| **Qualcomm Incorporated [5]** | **Proposal 1: Support simultaneous operation of 14 HARQ processes (RRC configured) and PDSCH repetition (RRC configured) without introducing any optimizations on top of Rel-16.*** **The fields *HARQ-ACK bundling flag*, *TB in a bundle* and *DCI subframe repetition number* retain their legacy functionality (i.e., Option 3 in the last FLS: 2 bits as in legacy)**
 |
| **Ericsson [6]** | **Observation 15 When the 14 HARQ processes feature is configured, it does not mean that 14 HARQ processes are always in use but rather that up to 14 HARQ processes can be used. Recall that in legacy the number of HARQ processes to be used changes dynamically via DCI. Moreover, even though this feature is meant to be used in good radio conditions, at a given point in time the number of HARQ processes required to transmit the DL data can change, and also the radio channel can suddenly change (e.g., because of shadowing).****Proposal 4 In Rel-17, for the 14 HARQ processes feature the “Repetition number” field is:****0-bits when the “HARQ-ACK bundling flag” is set to 1 (i.e., 2-bits from this field become available e.g., for joint-encoding purposes).** |

According with [2-6], three companies propose that the “Repetition number field” [2-4] will be 0-bits from the moment the 14 HARQ processes feature is configured, whereas the other two companies [5] and [6] highlight the importance of keeping available the usability of “Repetition number field” (either by controlling it through a flag or by not touching it at all) as to be able to act on the dynamic radio environment.

**Potential Agreement#2:**

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

        **Opt-1: 0-bits when the “HARQ-ACK bundling flag” is set to 1 (i.e., 2-bits from this field become available for jointly-encoding purposes).**

        **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** | Please state your views and technical reasons on which option you prefer: Opt-1, Opt-2, or Opt-3. | **Comments**  |
| Lenovo, MotoM | Opt-2(?) | As stated in E/// contribution in R1-2110317, before downselect the options, we should first decide whether to support the fallback DCI (e.g., no-bundling) if the 14HARQ configured.The design for this feature is mainly targeted for the HARQ-ACK bundle case, especially the 12PDCCH + 3 PUCCH timeline, that is why we have PDSCH scheduling delay of 2 and 7 instead of 5 6 8 etc.If we use legacy fallback DCI (e.g., no-bundling) in the Rel.17 structure (e.g., PDSCH scheduling delay of 2 and 7, HARQ process delay set), it will make a lot of resource waste (becuase the Rel.17 stucutre and fall back DCI can not match well), although we can contruct the scenarios to use the fallback DCI, the price is resource waste. Even bundling is enabled, we can dynamically indicate the bundling size of 1 (no bundle) with only loss of repetiton number dynamic configuration. Furthermore, If we want to support the PDSCH/PDCCH repetition in some scenarios, do we still need PUCCH repetition in these scenarios? Opt 2 can give us : 1 or more bit save and spec cleaner. I don’t think we should pay for 1 or more bits in DCI increasing, and the complicated texts in spec, especially in 213. |
| Nokia, NSB | Opt-2 | Slight preference for Opt-2. We are not sure that supporting the option of repetition (Ericsson Tdoc, proposal 6) justifies the additional complexity, for the scenarios where 14-HARQ is most likely to be configured. |
| ZTE, Sanechips | Opt-2 | Opt-1 requires the new design for the HARQ delay when bundling is not enabled. Moreover, more discussion/efforts to determine the HARQ delay is needed in the limited time and complexity is also increased.Opt-3 may increase the DCI size. The benefits including unified design and lower overhead for Opt-2 are observed from our view.Therefore, Opt-2 is preferred. |
| Qualcomm | Option 3 | We think legacy operation should be allowed – even when configured with 14 HARQs, the UE can be scheduled with repetitions. |
| Huawei, HiSilicon | Opt-2 | If 14-HARQ processes is configured for the UE, the channel condition is good enough and there is no need to dynamically indicate whether the PDSCH repetition field exists which may add additional complexility for DCI decoding. In addition, for fallback, there’s CSS for eMTC, eNB can still schedule UEs in CSS with repetition and without bundling. |
| Ericsson | Opt-1 or Opt-3 | Following a Semi-static approach as per Opt-2 will force us to perform a reconfiguration to address situations that change dynamically, which is not a suitable approach. It is therefore important to keep available the usability of the “Repetition number field”.Our first preference is Opt-1 because the usage/no-usage of the “Repetition number field” can be dinamically controlled which opens more possibilities.As a second option, Opt-3 would be our choice, since we prefer increasing the DCI size rather than losing flexibility and backward compatibility. |

### 2.3.2 “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 will be set to 0-bits depending on the status of the HARQ-ACK bundling flag (in this case it can be dynamically controlled whether to use the legacy HARQ-ACK delay or the Rel-17 HARQ-ACK delay), or if it will set to 0-bits from the moment the 14 HARQ process feature is configured.

**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 4: 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).** |
| **Nokia, Nokia Shanghai Bell [3]** | **Proposal 4: In Rel-17, 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 [4]** | ***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.*** |
| **Qualcomm [5]** | **Proposal 2: In Rel-17, for the 14 HARQ processes feature the “HARQ-ACK delay” field is:*** **Opt-2 (from last FLS): 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).**
 |
| **Ericsson [6]** | 1. In Rel-17, for the 14 HARQ processes feature the “HARQ-ACK delay” field is: 0-bits when the "HARQ-ACK bundling flag" is set to 1 (i.e., 3-bits from this field become available e.g., for joint-encoding purposes).
 |

**Potential Agreement#3:**

**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** | Please state your views and technical reasons on which option you prefer: Opt-1 or Opt-2. | **Comments**  |
| Lenovo, MotoM | Opt-2 |  |
| Nokia, NSB | Opt-2 |  |
| ZTE, Sanechips | Opt-2 |  |
| Qualcomm | Opt-2 |  |
| Huawei, HiSilicon | Opt-2 |  |
| Ericsson | Opt-1 but also depends on the resolution on the same matter for the “Repetition number” field. | Our first preference is Opt-1, because controlling dinamically the legacy DCI fields that are intended to be set to zero-bits opens more possibilities (e.g., we can pass dynamically from using the Rel-17 delays to legacy delays and viceversa, and using or not the PDSCH repetitions). |

## 2.4 Other topics

### 2.4.1 Search Space for the 14 HARQ processes feature

Background: In [5] and [6], the following proposals were made in relation with the search space to be used for the 14 HARQ processes feature:

**Table 5: Views on the Search Space for the 14 HARQ processes feature as in [2-6]**

|  |  |
| --- | --- |
| **Company** | **Search Space for the 14 HARQ processes feature: Compendium of views on the DCI fields that may be re-purposed [2-6].** |
| **Qualcomm Incorporated [5]** | **Proposal 3: Introduce the following specification changes for supporting 14 HARQ processes:****The PDSCH scheduling delay applies only to PDSCH scheduled from USS. The new fields in DCI do not apply to CSS**  |
| **Ericsson [6]** | Proposal 8 In Rel-17 for the 14 HARQ processes feature, the User Specific Search Space (USS) is used. |

**Potential Agreement#4:**

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

Companies are kindly requested to provide their views below:

|  |  |  |
| --- | --- | --- |
| **Company** | Please indicate whether you are Ok or not with Potential Agreement#4? | **Comments**  |
| Lenovo, MotoM | OK |  |
| Nokia, NSB | OK |  |
| ZTE, Sanechips | OK |  |
| Qualcomm | OK |  |
| Huawei, HiSilicon | OK |  |
| Ericsson | OK |  |

### 2.4.2 “HARQ-ACK process number” field: 4 bits

Background: Three companies propose to keep using as in legacy the “4-bits: HARQ-ACK process number field” [3], [5], and [6]:

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

|  |  |
| --- | --- |
| **Company** | **“HARQ-ACK delay” field: Compendium of views on the DCI fields that may be re-purposed [2-6].** |
| **Nokia, Nokia Shanghai Bell [3]** | **Proposal 5: In Rel-17, for the 14 HARQ processes feature the “HARQ 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).**
 |
| **Qualcomm Incorporated [5]** | **Proposal 3: Introduce the following specification changes for supporting 14 HARQ processes:*** **When 14 HARQ processes are enabled, the “HARQ process number” field in DCI format 6-1A is 4 bits.**
 |
| **Ericsson [6]** | **Proposal 7 In Rel-17, for the 14 HARQ processes feature the “HARQ 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).** |

**Potential Agreement#5:**

**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).**

Companies are kindly requested to provide their views below:

|  |  |  |
| --- | --- | --- |
| **Company** | Please indicate whether you are Ok or not with Potential Agreement#5? | **Comments**  |
| Lenovo, MotoM | OK |  |
| Nokia, NSB | OK |  |
| ZTE, Sanechips | OK |  |
| Qualcomm | OK |  |
| Huawei, HiSilicon | OK |  |
| Ericsson | OK |  |

### 2.4.3 Other specification changes for supporting the 14 HARQ processes feature

Background: In [5], additional changes required to support the 14 HARQ processes which have not been addressed in the earlier proposals were brought up.

**Table 7: Views other specification changes as in [5]**

|  |  |
| --- | --- |
| **Company** | **Views on other specification changes [5].** |
| **Qualcomm Incorporated [5]** | **Proposal 3: Introduce the following specification changes for supporting 14 HARQ processes:*** **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.**
 |

**Potential Agreement#6:**

**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.**

Companies are kindly requested to provide their views below:

|  |  |  |
| --- | --- | --- |
| **Company** | Please indicate whether you are Ok or not with Potential Agreement#6? | **Comments**  |
| Lenovo, MotoM | OK |  |
| Nokia, NSB | Ok |  |
| ZTE, Sanechips | OK |  |
| Qualcomm | OK |  |
| Huawei, HiSilicon | OK |  |
| Ericsson | OK |  |

Note: Other proposals in [5] are more suitable to be discussed as part of the Rel-17 RRC parameter list e-mail discussion.

# 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. [R1-2108778](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2108778.zip), “Support of 14-HARQ processes in DL for HD-FDD MTC UEs,” Huawei, HiSilicon, RAN1 #106bis-e, October 11th – 19th, 2021.
3. [R1-2109315](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2109315.zip), “Support of 14-HARQ processes in DL for eMTC,” Nokia, Nokia Shanghai Bell, RAN1 #106bis-e, October 11th – 19th, 2021.
4. [R1-2109338](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2109338.zip), “Remaining issues on 14-HARQ processes in DL for eMTC,” ZTE, RAN1 #106bis-e, October 11th – 19th, 2021.
5. [R1-2109175](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2109175.zip), “Support of 14 HARQ processes and scheduling delay,” Qualcomm Incorporated, RAN1 #106bis-e, October 11th – 19th, 2021.
6. [R1-2110317](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106b-e/Docs/R1-2110317.zip), “Support of 14 HARQ processes in DL in LTE-MTC,” Ericsson, Verizon, Telefónica, SoftBank, Telstra, RAN1 #106bis-e, October 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.

# 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.