3GPP TSG-RAN WG1 Meeting #105-e R1-21xxxxx

e-Meeting, May 10th – 27th, 2021

Agenda Item: 8.9.2

Source: Moderator (Ericsson)

Title: Feature Lead Summary on [105-e-LTE-Rel17\_NB\_IoT\_eMTC-02]

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]
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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], and RAN1 #104-bis-e [10].

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

## 2.1 HARQ-ACK delay

Background: In relation with the “HARQ-ACK delay” solution, in RAN1 #104-bis-e the following agreement was reached [10]:

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| **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 bitmaps1. Robustness against loss of DCIs
2. Flexibility
3. RRC signaling overhead
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In line with the previously cited agreement, companies made the following proposals as described in [2-6]:

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| **Company** | **Down-selection between Alt-1 and Alt-2 for the HARQ-ACK delay solution according with [2-6].** |
| **Huawei, HiSilicon [2]** | **Proposal 1: For Alt-1, the solution of HARQ-ACK delay values *y* is:*** ***(y-2) DL BL/CE subframes+1 subframe+1 UL BL/CE subframes. y ranges from 10-13.***
* ***(y-3) DL BL/CE subframes+1 subframe+2 UL BL/CE subframes. y ranges from 7-10.***
* ***(y-4) DL BL/CE subframes+1 subframe+3 UL BL/CE subframes. y ranges from 4-7.***

**Proposal 2: Support Alt-1 for the solution of HARQ-ACK delay values.**  |
| **Nokia, Nokia Shanghai Bell [3]** | **Proposal 1: In Rel-17, for the 14 HARQ process feature, the HARQ-ACK delay solution is determined through an expression consisting of different subframe types.****Proposal 2: The HARQ-ACK PUCCH assigned to a given HARQ process, is determined by the UE using the expression below given 2 delay parameters, y and z, signaled by the gNB to the network via the DCI,**  **(y) BL/CE DL subframe + 1 subframe (any type) + (z) BL/CE UL subframes.** ***Where:**** + - * ***y = {0,1,2,…,11}***
			* ***z = {1,2,3}***
 |
| **ZTE [4]** | ***Proposal 2: For 14 HARQ processes, the “HARQ-ACK delay” is kept expressed in terms of “absolute subframes”.**** ***The HARQ-ACK delay value range is 4~17 for PDSCH scheduling delay of 2.***
* ***The HARQ-ACK delay value range is 12~19 for PDSCH scheduling delay of 7.***
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| **Qualcomm Incorporated [5]** | **Proposal 1: In Rel-17, for the 14 HARQ process feature the HARQ-ACK delay solution is:*** **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”.**
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| **Ericsson [6]** | 1. **The HARQ-ACK delay should be a future-proof solution able to handle realistic scenarios accounting for at least 30% to 40% presence of non-BL/CE subframes as to accommodate the co-existence with NR.**
2. **In line with proposal 1, if the HARQ-ACK delay solution were to be based on Alt-1, then a 4-bit deterministic approach should be used to provide a trade-off between flexibility, signalling overhead (total number of bits), and keeping the ability of handling any percentage of presence of invalid subframes.**

**HARQ-ACK delay (4-bits):****0000 11 BL/CE DL subframes + 1 subframe + 1 BL/CE UL subframe****0001 10 BL/CE DL subframes + 1 subframe + 1 BL/CE UL subframe****0010 9 BL/CE DL subframes + 1 subframe + 1 BL/CE UL subframe****0011 8 BL/CE DL subframes + 1 subframe + 1 BL/CE UL subframe****0100 7 BL/CE DL subframes + 1 subframe + 2 BL/CE UL subframe****0101 6 BL/CE DL subframes + 1 subframe + 2 BL/CE UL subframe****0110 5 BL/CE DL subframes + 1 subframe + 2 BL/CE UL subframe****0111 4 BL/CE DL subframes + 1 subframe + 2 BL/CE UL subframe****1000 3 BL/CE DL subframes + 1 subframe + 3 BL/CE UL subframe****1001 2 BL/CE DL subframes + 1 subframe + 3 BL/CE UL subframe****1010 1 BL/CE DL subframes + 1 subframe + 3 BL/CE UL subframe****1011 1 subframe + 3 BL/CE UL subframes****1100 1 subframe + 1 BL/CE UL subframes****1101 1 BL/CE DL subframe + 1 subframe + 1 BL/CE UL subframes****1110 2 BL/CE DL subframe + 1 subframe + 1 BL/CE UL subframes****1111 3 BL/CE DL subframe + 1 subframe + 1 BL/CE UL subframes****FFS: Signaling Details (i.e., DCI design)**1. **In line with proposal 1, if the HARQ-ACK delay solution were to be based on Alt-2, then the “HARQ-ACK delay” field should use 4-bits in total as to include the legacy HARQ-ACK delays when “ce-HARQ-AckBundling” is set, plus eight new delay values including at least a delay value equal 20:**

**HARQ-ACK delay set (4-bits):****{4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20}****FFS: Signaling Details (i.e., DCI design).****FFS: If a 5-bits “HARQ-ACK delay set” is to be added to handle 40ms bitmaps.** |

In RAN1# 104-bis-e five technical aspects were agreed to 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*”. Below an analysis of the five technical aspects is provided by the Feature Lead (FL) comparing one-on-one the proposals under the umbrella of Alt-1 and Alt-2 as described in [2-6].

**Table 1: Summary: Technical comparison between Alt-1 and Alt-2.**

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| **General Description** | **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). | **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”. |
| **Alt-1 as in [2]:*** *(y-2) DL BL/CE subframes+1 subframe+1 UL BL/CE subframes. y ranges from 10-13.*
* *(y-3) DL BL/CE subframes+1 subframe+2 UL BL/CE subframes. y ranges from 7-10.*
* *(y-4) DL BL/CE subframes+1 subframe+3 UL BL/CE subframes. y ranges from 4-7.*
 | **Alt-1 as in [3]:**2 delay parameters, y and z, signaled by the eNB to the network via the DCI, (y) BL/CE DL subframe + 1 subframe (any type) + (z) BL/CE UL subframes. Where:* y = {0,1,2,…,11}
* z = {1,2,3**}**
 | **Alt-1 as in [6]:**HARQ-ACK delay (4-bits):0000 11 BL/CE DL subframes + 1 subframe + 1 BL/CE UL subframe0001 10 BL/CE DL subframes + 1 subframe + 1 BL/CE UL subframe0010 9 BL/CE DL subframes + 1 subframe + 1 BL/CE UL subframe0011 8 BL/CE DL subframes + 1 subframe + 1 BL/CE UL subframe0100 7 BL/CE DL subframes + 1 subframe + 2 BL/CE UL subframe0101 6 BL/CE DL subframes + 1 subframe + 2 BL/CE UL subframe0110 5 BL/CE DL subframes + 1 subframe + 2 BL/CE UL subframe0111 4 BL/CE DL subframes + 1 subframe + 2 BL/CE UL subframe1000 3 BL/CE DL subframes + 1 subframe + 3 BL/CE UL subframe1001 2 BL/CE DL subframes + 1 subframe + 3 BL/CE UL subframe1010 1 BL/CE DL subframes + 1 subframe + 3 BL/CE UL subframe1011 1 subframe + 3 BL/CE UL subframes1100 1 subframe + 1 BL/CE UL subframes1101 1 BL/CE DL subframe + 1 subframe + 1 BL/CE UL subframes1110 2 BL/CE DL subframe + 1 subframe + 1 BL/CE UL subframes1111 3 BL/CE DL subframe + 1 subframe + 1 BL/CE UL subframes | **Alt-2 as in [4]:***The HARQ-ACK delay value range is 4~17 for PDSCH scheduling delay of 2.* *The HARQ-ACK delay value range is 12~19 for PDSCH scheduling delay of 7.* | **Alt-2 as in [5]:****Alt-2\_v1:** Using 4 bits, we can signal all possible HARQ-ACK delays between 4 and 19**Alt-2\_v2:** Using 5 bits, we can signal all possible HARQ-ACK delays between 4 and 35 | **Alt-2 as in [6]:**HARQ-ACK delay set (4-bits):{4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20}FFS: If a 5-bits “HARQ-ACK delay set” is to be added to handle 40ms bitmaps. |
| 1. **Total number of bits required in DCI**
 | **Alt-1 as in [2]:**4-bitsNote: “y” ranges from 4 to 13 as to resemble 12 HARQ-ACK delay expressions, which requires 4-bits. | **Alt-1 as in [3]:**6-bitsNote: “y” ranges from 0 to 11 whereas “z” ranges from 1 to 3, which requires 4-bits. | **Alt-1 as in [6]:**4-bitsNote: Alt-1 as in [6] directly signals 16 deterministic expressions consisting of different subframe types as to use 4-bits. | **Alt-2 as in [4]:**4-bitsNote: The range 4 – 19 requires 4-bits. | **Alt-2 as in [5]:****Alt-2\_v1:** 4-bits **Alt-2\_v2:** 5-bitsNote: The range 4 – 19 requires 4-bits, whereas the range 4 – 35 requires 5-bits. | **Alt-2 as in [6]:**4-bits (5-bits for 40ms bitmaps)Note: 4-bits are required for the HARQ-ACK delay set: {4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20}. Longer delays are needed for 40ms bitmaps, for which 5-bits are proposed to be used. |
| **Note: The estimated Total number of bits strictly refer to the proposed Alt-1/Alt-2 solutions as described in [2-6], without involving any possible jointly encoding DCI design strategy that may or may not be adopted.** |
| 1. **Scenarios that can be handled, including:**
 | 1. **different numbers of scheduled HARQ processes per burst (including dynamically switching between more than 10 HARQ processes and 10 or less HARQ processes)**
 |
| (a) is fulfilled by **Alt-1 as in [2]** but the single HARQ process scenario will account for 3 BL/CE UL subframes instead of 1. | (a) is fulfilled by **Alt-1 as in [3].** | (a) is fulfilled by **Alt-1 as in [6].** | (b) is fulfilled by **Alt-2 as in [4]** in the same way that legacy does. | (b) is fulfilled by **Alt-2 as in [5]** in the same way that legacy does. | (b) is fulfilled by **Alt-2 as in [6]** in the same way that legacy does. |
| 1. **different % of invalid subframes for both 10 and 40 SF long bitmaps**
 |
| (b) is fulfilled by **Alt-1 as in [2]** since it can handle any percentage of presence of invalid subframes regardless of the bitmap length. | (b) is fulfilled by **Alt-1 as in [3]** since it can handle any percentage of presence of invalid subframes regardless of the bitmap length. | (b) is fulfilled by **Alt-1 as in [6]** since it can handle any percentage of presence of invalid subframes regardless of the bitmap length. | **Alt-2 as in [4] ⁓**35.29% handling of non-BL/CE DL subframes, whereas with simultaneous presence of two non-BL/CE UL subframes the handling drops to ⁓26.67%. | **Alt-2 as in [5]** **Alt-2\_v1: ⁓**35.29% handling of non-BL/CE DL subframes, whereas with simultaneous presence of two non-BL/CE UL subframes the handling drops to ⁓26.67%**Alt-2\_v2: ⁓**66.67% handling of non-BL/CE DL subframes, whereas with simultaneous presence of two non-BL/CE UL subframes the handling slightly drops to ⁓64.52% | **Alt-2 as in [6] ⁓**38.89% handling of non-BL/CE DL subframes, whereas with simultaneous presence of two non-BL/CE UL subframes the handling drops to ⁓31.25% |
| 1. **Robustness against loss of DCIs**
 | As long as the Alt-1 solution signals the HARQ-ACK delay expression and not only the designated PUCCH it will be robust “*against loss of DCIs*”, which is the case of **Alt-1 as described in [2], [3], and [6].** Nonetheless, is important to keep in mind that the more the DCI bits used by the solution the higher are the chances of impacting the BLER performance of the MPDCCH (On this matter, re-using existing fields will help to alleviate this issue). | For **Alt-2 as described in [4], [5], and [6]**, the “Robustness against loss of DCIs” will be in principle as in legacy. Nonetheless, is important to keep in mind that the more the DCI bits used by the solution the higher are the chances of impacting the BLER performance of the MPDCCH (On this matter, re-using existing fields will help to alleviate this issue). |
| 1. **Flexibility**
 | **Alt-1 as in [2]** has a **Medium-to-Low Flexibility** since the single HARQ process scenario will account for 3 BL/CE UL subframes instead of 1. | **Alt-1 as in [3]** has **Full Flexibility.** | **Alt-1 as in [6]** has a **Medium Flexibility** since the single HARQ process scenario will account for 1 BL/CE UL subframes as it is supposed to be. | **Alt-2 as in [4]** has a **Medium-to-Low Flexibility** since the percentage of invalid subframes it can handle won’t be flexible enough to accommodate e.g., the co-existence with NR. | **Alt-2 as in [5]:****Alt-2\_v1** has a **Medium-to-Low Flexibility** since the percentage of invalid subframes it can handle won’t be flexible enough to accommodate e.g., the co-existence with NR.**Alt-2\_v2** has a **High Flexibility** since the percentage of invalid subframes it can handle will be flexible enough to accommodate e.g., the co-existence with NR. | **Alt-2 as in [6]** has a **Medium Flexibility** since the percentage of invalid subframes it can handle will be just in the limit as to be flexible enough to accommodate e.g., the co-existence with NR. |
| 1. **RRC signaling overhead**
 | The RRC signaling is not an essential component of Alt-1 nor Alt-2, since primarily dynamic signalling is needed rather than semi-static signalling. The latter (i.e., RRC signalling) if any may be used as a second order aspect to add more options that can be changed via semi-static RRC re-configuration. |
| None**Alt-1 as described in [2], [3], and [6]** require dynamic signaling via DCI. | None No RRC signaling required according with **Alt-2 as in [4]:** | “Yes (depends on details)” for **Alt-2 as in [5]:** | N/A |

**Potential Agreement:**

**In Rel-17, for the 14 HARQ process feature the HARQ-ACK delay solution will be based on:**

**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).**

* + **The expression(s) consisting of different subframe types will be based in one of the following Alt-1 frameworks to be down-selected in RAN1#105-e:**
		- **Alt-1a: “4-bits Alt-1 as in [2]” or**
		- **Alt-1b: “6-bits Alt-1 as in [3]” or**
		- **Alt-1c: “4-bits deterministic Alt-1 as in [6]”.**
	+ **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”.**

* + **The HARQ-ACK delay values and the length of the HARQ-ACK delay set will be based in one of the following Alt-2 frameworks to be down-selected in RAN1#105-e:**
		- **Alt-2a: “4-bits (max delay = 19) Alt-2 as in [4]” or**
		- **Alt-2b: “4-bits (max delay = 19) Alt-2\_v1 as in [5]” or**
		- **Alt-2c: “5-bits (max delay = 35) Alt-2\_v2 as in [5]” or**
		- **Alt-2d: “4-bits (max delay = 20) Alt-2 as in [6]”.**
		- **Alt-2e: “3 bits (same as legacy)”**
	+ **FFS: Signaling Details.**

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| **Company** | **Alt-1 (framework a, b, or c?) or Alt-2 (framework a, b, c, or d?)?** | **Comments**  |
| Nokia, NSB | Alt-1 | We prefer Alt.1, as we can envisage issues/limitations with Alt-2, particularly where 40 SF long invalid bitmaps are concerned.Out of the alternative variants of Alt1, given🡪 This feature is likely to be used most in better channel conditions🡪 The overall size increase in DCI bits could be limited:* + - by joint encoding
		- repurposing of redundant dci fields (HARQ-ack bundling, PUSCH repetition,…)

🡪 DCI robustness can be increased using higher AL without specification changeswe have a **slight preference** for the fully flexible option 1B.**Other variants of Alt-1**However, if DCI size is considered a serious issue to the group, we would like to highlight that there are many other variants of ALT-1, that could be constructed that trade-off differently the:Number of DCI bits versus Flexibility of PUCCH allocation **E.g. Alt-1d: 5 bits based on 1b but where when y=11, z can only be 1 and/or when y=0, z can only be 3, i.e. the first and last HARQ processes are restricted to the first and last HARQ-ACK bundles respectively.Supporting multiple variants of Alt-1**Another option for the group to consider, is whether to support more than 1 variant of Alt-1, which could be configured by RRC |
| Ericsson | **Alt-2c: “5-bits (max delay = 35) Alt-2\_v2 as in [5]”** | Alt-2 is only OK with us as per **Alt-2c: “5-bits (max delay = 35) Alt-2\_v2 as in [5]”.** Basically since it fulfils being a future-proof solution, while keeps the legacy framework.Otherwise, if **Alt-2c** were not agreeable then probably Alt-1c: “4-bits deterministic Alt-1 as in [6]” would be a good trade-off if Alt-1 were to be chosen. |
| Lenovo,MotoM | **Alt-2a: “4-bits (max delay = 19)** | First, we hope we can follow the legacy HARQ-ACK delay counting based on absolute subframe.Secondly, if we want to support more HARQ-ACK delay value considering the invalid subframe, alt-2a is a good tradeoff. Because the HARQ-ACK delay is largely related to PDSCH scheduling delay. Different HARQ-ACK delay set for different PDSCH scheduling delay seems more reasonable. |
| Qualcomm | Alt-2e or configurable between {2e, other} | First, we added to the list of options the legacy 3-bit delay, which is able to handle the case of very small number of invalid subframes (which we think is the usual deployment).Now, we would like to clarify a couple of things:- Companies are proposing to account for the case where a large number of invalid subframes are present (e.g. for 5 bits, we can handle >60% invalid subframes). We would be really surprised if any practical deployment had this configuration. We think Alt-2e should be the baseline.- If companies want to account for these large number of invalid subframes, we should allow to **configure a smaller value** as well. For example, we could configure between Alt-2a and Alt-2e. A network with almost no invalid subframes (which we think would be the usual case) would use the smaller overhead, and we would still have the flexibility to configure a larger number of bits if in the future networks need to reserve a lot of subframes.- Although we are designing this field independently, we think that some additional flexibility could be achieved if we do **joint encoding of this field with the PDSCH delay field** (Lenovo seems to propose this as well). The PDSCH delay field, in our understanding, will be signaled among {2, 7v1, 7v2}. Using 2 bits to signal this would be a waste of one combination. If we use 5 bits to signal PDSCH scheduling delay and HARQ-ACK delay, we could signal 10 HARQ-ACK delays for every PDSCH delay (vs 8 in separate encoding of 2+3). For the 6-bit case, we would have 21 HARQ-ACK delays for every PDSCH delay (vs 16 in separate encoding of 2+4). |
| ZTE, Sanechips | Alt-2a: “4-bits (max delay = 19) | For Alt-2a and other alternatives, the number of required DCI bits may be reduced by optimizing DCI signaling design. We suggest to handle HARQ-ACK delay solution and DCI signaling of HARQ-ACK delay and PDSCH scheduling delay together.If HARQ-ACK delay set can be separately defined for different PDSCH scheduling delays, by using joint coding, the DCI signaling overhead can be minimized. |
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## 2.2 DCI Design

Background: In [2-6], it is possible to find several proposals on how many bits to use for both the PDSCH scheduling delay and HARQ-ACK delay, which DCI fields can be possibly re-purposed, etc. However, for the moment the FL has the following recommendation.

**For the DCI Design, it is recommended to wait until RAN1 has reached an agreement on whether Alt-1 or Alt-2 will be the HARQ-ACK delay solution.**

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| **Company** | **OK?** | **Comments** |
| Nokia, NSB | Yes | Agree with FL |
| Ericsson | Yes |  |
| Lenovo, MotoM | Yes | Agree with FL |
| Qualcomm | Yes |  |
| ZTE, Sanechips |  | The principle of DCI design should be considered together with downselection of HARQ-ACK solution. For example, number of additional DCI bits allowed? Joint coding? etc |

## 2.4 Clarification on PUCCH with R=1: Postponement or No Postponement

Background: In RAN1# 104-bis-e [2], it was discussed whether the legacy behaviour of PUCCH (when Repetition = 1) of no postponing the UL transmission in presence of a non-BL/CE UL subframes will be or not followed. The decision was left open since depending on whether the HARQ-ACK delay solution will follow Alt-1 or Alt-2, the legacy behaviour of PUCCH (when Repetition = 1) may end up being irrelevant. The potential agreement from RAN1#104-bis was captured as follows:

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| **Potential Agreement:****In Rel-17, for the 14 HARQ processes feature:*** **Opt-1: PUCCH using Repetition = 1 is not postponed (legacy behavior).**
* **Opt-2: PUCCH using Repetition = 1 is postponed.**
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In [2-6], the following observations and proposal related with the “Clarification on PUCCH with R=1: Postponement or No Postponement” were found:

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| **Company** | **Clarification on PUCCH with R=1: Postponement or No Postponement** |
| **Huawei, HiSilicon [2]** | **N/A** |
| **Nokia, Nokia Shanghai Bell [3]** | **Proposal 7: In Rel-17, for the 14 HARQ processes feature, in the event of a collision between PUCCH (Repetition=1) and a non-BL/CE UL subframe, the PUCCH is postponed.** |
| **ZTE [4]** | **N/A** |
| **Qualcomm Incorporated [6]** | **N/A** |
| **Ericsson [7]** | **Observation 19: If the HARQ-ACK delay solution follows Alt-1 the legacy behavior of PUCCH (when Repetition = 1) will be fully overridden, whereas if the HARQ-ACK delay solution follows Alt-2 the legacy behavior of PUCCH (when Repetition = 1) will be partially overridden letting just the legacy behavior possibly usable when 10 or less HARQ processes will be in use.****Observation 20: Given that the legacy behavior of PUCCH (when Repetition = 1) will be either fully (Alt-1) or at least partially (Alt-2) overridden, it is preferred to avoid mixed behaviors in case Alt-2 were selected.****Proposal 4: In Rel-17, for the 14 HARQ processes feature:****• PUCCH using Repetition = 1 is postponed.** |

**For the “Clarification on PUCCH with R=1: Postponement or No Postponement” it is recommended to wait until RAN1 has reached an agreement on whether Alt-1 or Alt-2 will be the HARQ-ACK delay solution.**

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| **Company** | **OK?** | **Comments** |
| **Nokia, NSB** |  | Can wait, however we do not see our view (assume postponment) being dependent on the Alt chosen. |
| **Ericsson** | **Yes** | In our view keeping the legacy PUCCH with R=1 No Postponement touches (at least to some extent) upon the Alternative to be chosen as solution for the HARQ-ACK delay. Hence, it is fine with us to wait. |
| **Lenovo,MotoM** | **Yes** | If alt 1 is adopted, there is no such issue, because only valid subframe is counted, right?If alt 2 is adopted, e.g., HARQ-ACK delay is counted by absolute subframes. For example, if HARQ-ACK delay=8 indicated by DCI, the corresponding subframe#20 is not valid, * option 1: postpone the HARQ-ACK to next valid subframe, for example subframe #22
* option 2: directly HARQ-ACK delay =10 indicated by DCI, fully controlled by eNB scheduling

Although we admit the option 1 can handle more invalid subframe cases (implicitly add more HARQ-ACK delay values by postponement), we slightly prefer to follow legacy bahiour and make the spec easier to read. |
| **Qualcomm** | **Yes** |  |
| **ZTE, Sanechips** | **Yes** |  |

# 5 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. [R1-2104289](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104289.zip), “Support of 14-HARQ processes in DL for HD-FDD MTC UEs,” Huawei, HiSilicon, RAN1 #105-e, May 10th – 27th, 2021.
3. [R1-2104549](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104549.zip), “Support of 14-HARQ processes in DL for eMTC,” Nokia, Nokia Shanghai Bell, RAN1 #105-e, May 10th – 27th, 2021.
4. [R1-2104717](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104717.zip), “Remaining issues on 14-HARQ processes in DL for eMTC,” ZTE, RAN1 #105-e, May 10th – 27th, 2021.
5. [R1-2104821](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104821.zip), “Support of 14 HARQ processes and scheduling delay,” Qualcomm Incorporated, RAN1 #105-e, May 10th – 27th, 2021.
6. [R1-2105890](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105890.zip), “Support of 14 HARQ processes in DL in LTE-MTC,” Ericsson, Verizon, Telefónica, SoftBank, Telstra, RAN1 #105-e, May 10th – 27th, 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.

# 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