**3GPP TSG-RAN WG1 Meeting #106-eR1-210XXXX**

e-Meeting, Aug 16th – 27th, 2021

**Agenda item: 8.3.1.1**

**Source: Moderator (Nokia)**

**Title: Moderator summary #X on HARQ-ACK feedback enhancements for NR Rel-17 URLLC/IIoT**

**Document for: Discussion and Decision**

# Introduction

As per chairman’s guidance, the email discussion is planned according to the following schedule:

[106-e-NR-R17-IIoT-URLLC-01] Email discussion on UE feedback enhancements for HARQ-ACK – Klaus (Nokia)

* 1st check point: August 19
* 2nd check point: August 25
* 3rd check point: August 27

**This document is structured as follows:**

* Sections 2 to 6 include the topics to be specified or at least further studied based on previous agreements, including sub-sections for the related email discussion rounds
  + Please note, that HARQ-ACK payload size reduction is not in focus any longer based on the RAN#92 guidance (see section 3.2 of [RP-211569](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_92e/Docs/RP-211569.zip))
* There are two appendices, Appendix A containing the RAN1 agreements reached in AI 8.3.1.1 so far and Appendix B summarizing the companies’ proposals for easier referencing.

# SPS HARQ-ACK deferral for TDD

In this section, the proposed Rel-17 enhancements to prevent SPS HARQ-ACK deferral for TDD operation are summarized. The following related agreements from previous meetings are available on this topic:

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| Agreements: To address the issue of SPS HARQ-ACK dropping for TDD systems, focus on the following two options:   * Option 1: Deferring HARQ-ACK until a next (e.g., first) available PUCCH   + FFS: Details including the definition of a next (e.g, first) available PUCCH, CB construction / multiplexing * Option 2: Dynamic triggering of a one-shot / Type-3 CB type of re-transmission   FFS: Details on triggering and/or CB construction (incl. potential Type-3 CB optimizations) / multiplexing  Agreements:   * Support deferring SPS HARQ-ACK dropped due to TDD specific collisions until a next available PUCCH in Rel-17 based on semi-static configuration of slot format   + FFS: Details (including possible conditions for such a deferring, whether or not to consider semi-statically configured flexible symbols for PUCCH availability, etc.)   + Aim for minimal standardization efforts and UE complexity in implementation   Agreements:  Further down-select between the following two options for SPS HARQ-ACK deferral:   * Option 1: Joint RRC configuration of the SPS HARQ-ACK deferral per PUCCH cell group   + *Note: any SPS HARQ-ACK within a PUCCH cell group in principle is subject to deferral* * Option 2: The SPS HARQ-ACK deferral is configured per SPS configuration   + *Note: part of sps-config, only HARQ-ACK of SPS PDSCH configurations configured for deferral is in principle subject to deferral*   Agreements: Rel-16 UCI multiplexing  / PUCCH overriding rules are reused for deferred SPS HARQ-ACK in the target slot, if applicable.  Agreements: For SPS HARQ-ACK, the deferral from the initial slot/sub-slot determined by *k1* in the activation DCI to the target slot/sub-slot determined by *k1*+ *k1def*, the UE will check the validity of a target slot/sub-slot evaluating from one slot/sub-slot to the next sub/sub-slot (i.e. in principle *k1def* granularity is 1 slot/sub-slot)   * FFS: if there is a limit on the minimum deferral considered the required UE processing (*k1def* ≥0) * FFS: if there is a limit on the maximum deferral   Agreements: For SPS HARQ-ACK deferral, for the determination of valid symbols in the initial slot/sub-slot a collision with semi-static DL symbols, SSB and CORESET#0 is regarded as ‘invalid’ or ‘no symbols for UL transmission’.  Agreements: For SPS HARQ-ACK deferral, for the determination of valid symbols in the target slot/sub-slot a collision with semi-static DL symbols, SSB and CORESET#0 is regarded as ‘invalid’ or ‘no symbols for UL transmission’.  Agreements: For SPS HARQ-ACK deferral, support a limit on the maximum deferral of SPS HARQ in terms of *k1def* or *k1*+ *k1def*   * + FFS: limitation given by a maximum value of *k1def* or a maximum of *k1eff* =*k1*+ *k1def*   + FFS how the limitation is determined (e.g. by K1 set(s) or RRC configured limit)   Agreements: For SPS HARQ-ACK deferral, there is no lower limit defined for *k1def*  Agreement: Restrict the further discussions on the initial slot handling for SPS HARQ-ACK deferral to the identified alternatives Alt. 1, Alt. 1A and 2.  Agreement: For SPS HARQ-ACK deferral, the limit on the maximum deferral of SPS HARQ is defined in terms of *k1eff =k1*+ *k1def.*  Working assumption: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:   * In case the UE receives PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.   Agreement: For SPS HARQ-ACK deferral, the initial HARQ-ACK transmission occasion is considered to determine the out-of-order HARQ condition |

* 1. Summary of companies input in their contributions

**RRC configuration of SPS HARQ-ACK deferral:**

* **Alt. 1 – per PUCCH group (3):** China Telecom [11], Mediatek [20], DoCoMo [26]
* **Alt. 2 – per SPS configuration (14):** vivo [2],Nokia/NSB [3], Ericsson [4], Spreadtrum [5], ZTE [6], Panasonic [10], OPPO [14], Qualcomm [16], LGE [18], ETRI [19], Intel [21], Sharp [24], TCL [25], CAICT [29]

**Maximum deferral value of k1+k1def =k1eff,max is determined as:**

* **Alt. 1 (5): Maximum k1 value in dl-DataToUL-ACK (5):** Huawei/HiSi [1], vivo [2], OPPO [14] (of the DCI format activating the SPS configuration), Mediatek [20], TCL [25]
  + **k1+k1def corresponds to a valid k1 in dl-DataToUL-ACK (3):** vivo [2], LGE [18], TCL [25]
* **Alt. 2 (6): RRC configured:** Nokia/NSB [3] (per SPS configuration, value range up to 15), Spreadtrum [5], FGI/APT [15], Qualcomm [16], Intel [21], DoCoMo [26] (per SPS configuration)
  + In case of a PUCCH transmission containing HARQ-ACK bits from different SPS configurations with different maximum deferral values, the maximum of those maximum deferral values is applied: Qualcomm [16]
* **Alt. 3 (1): Maximum value not defined but just given by the first available UL slot/sub-slot:** ZTE [6]
* **Additional input:** 
  + For PUCCH repetition, the maximum deferral value is applied per PUCCH repetition occasion: OPPO [14], ETRI [19] (?)
  + If having SPS HARQ to be deferred with different k1eff, instead of dropping a subset of SPS HARQ, follow the last valid window of the SPS HARQ-ACK: ETRI [19]

**Definition of when to defer from the initial slot:**

* **Alt. 1 (11 Yes – 1 No)- Deferral only, if the SPS HARQ-ACK in the initial slot/sub-slot cannot be transmitted as the resulting PUCCH resource for transmission using the PUCCH by SPS-PUCCH-AN-List-r16 or n1PUCCH-AN is not valid:** Huawei /HiSi[1], vivo [2], Nokia/NSB [3], Sony [7], Panasonic [10] (1st preference), NEC [12], Lenovo/Motorola [13], OPPO [14], FGI/APT [15], DoCoMo [26], CAICT [29] – No: Intel [21]
  + **Moderator understanding:** *If SPS HARQ-ACK is multiplexed with e.g. dynamic PUCCH resource then it cannot be deferred. Needed discussion on handling of other configured PUCCH (such as CSI resources, see below)*
  + Additional info:
    - multi-CSI-PUCCH-ResourceList, as well as pucch-CSI-ResourceList, is supported as candidate PUCCH resource(s) when performing SPS HARQ-ACK multiplexing with CSI: vivo [2], Nokia/NSB [3] (at least consider), CAICT [29]
    - Deferal decision should be done before the multiplexing decision: OPPO [14]
    - SPS PUCCH resources carrying N bits can be used as the candidates to check the validity of a SPS PUCCH resource for M-bit SPS HARQ-ACK associated to a slot, where N≥M: OPPO [14]
      * *Moderator question*: As the UE would be allowed to use a different, larger SPS PUCCH resource, would this then actually not be more Alt. 2 operation?
* **Alt. 1A (6x Yes): Deferral only, if the PUCCH resource configured by *SPS-PUCCH-AN-List-r16* or *n1PUCCH-AN* for the HARQ-ACK transmission assuming SPS HARQ-ACK only is not valid in the initial slot/sub-slot:** Huawei /HiSi[1], Ericsson [4], ZTE [6], CATT [9], Panasonic [10] (2nd preference), LGE [18] – **No**:
  + **Moderator understanding:** *Defer SPS HARQ even if multiplexing & transmission based e.g on PRI in initial slot would be possible – i.e. deferral decision is done before the multiplexing decision*
  + Additional info:
    - Deferral decision should be done before the multiplexing decision**:** ZTE [6]
    - Modification to Alt. 1A: UE could still defer to dynamically scheduled PUCCH within the initial slot: ZTE [6]
    - Modification to Alt. 1A: SPS HARQ-ACK can be still be multiplexed and transmitted in the initial slot (no changes to UCI multiplexing in the initial slot) in addition to the deferral: LGE [18]
    - Consider in addition semi-statically scheduled PUCCH transmission (CSI & SR) in the deferral condition: LGE [18]
* **Alt. 2 (8x Yes – 1x No): Deferral only, if the SPS HARQ-ACK in the initial slot/sub-slot cannot be transmitted as the resulting PUCCH resource for transmission using SPS-PUCCH-AN-List-r16, n1PUCCH-AN or other configured PUCCH resource(s) is not valid:** Spreadtrum [5],Samsung [8], China Telecom [11], Qualcomm [16], Intel [21], TCL [25], Xiaomi [27], CAICT [29] – **No:** LGE [18]
  + **Moderator understanding:** *Consider intra-slot deferral before inter-slot deferral*

Additional info:

* + Other configured PUCCH resources:
    - *PUCCH-ResourceSet:* Spreadtrum [5]
    - *multi-CSI-PUCCH-ResourceList:*Spreadtrum [5], CAICT [29]
  + Apply some default rules to choose one resource: Spreadtrum [5] (smallest resource index or earliest starting symbols)
* **Other:** 
  + If an SPS HARQ-ACK PUCCH is determined to collide with the semi-statically configured flexible symbol in the slot, the SPS HARQ-ACK PUCCH should be transmitted: ZTE [6]
  + If a PUCCH for SPS HARQ ACK info is dropped due to overlapping with DL or flexible symbol indicated by dynamic SFI, the “SPS HARQ ACK deferral to 1st available PUCCH” will not be applied to this case, i.e. no further deferral for this dropped PUCCH: Qualcomm [16]
  + If a PUCCH containing HARQ-ACK & CSI is dropped, only the HARQ-ACK is deferred (the CSI is dropped): Qualcomm [16]
  + Some semi-static flexible symbols can be configured to be ‘invalid’: ETRI [19]
  + The decision on the deferral scheme / condition may be dependent on the gNBs PUCCH blind detection capability: CAICT [29]
  + gNB configures if UL symbols indicated by SFI are ‘valid’ or ‘invalid’: CAICT [29]
  + Support partial deferral of bits (N-N1 bits transmitted in initial slot, N2 bits are deferred): CAICT [29]

**Definition of next available PUCCH for inter-slot/sub-slot deferral (i.e. target slot):**

* **The earlier of *sps-PUCCH-AN-List-r16* or  *n1PUCCH-AN,* or a dynamically indicated PUCCH resource *(from*** ***PUCCH-ResourceSet*) (6):** vivo [2],Nokia/NSB [3], ZTE [6], TCL [25], DoCoMo [26], CAICT [29] (?)

Additional details:

* + *multi-CSI-PUCCH-ResourceList*, as well as *pucch-CSI-ResourceList* considered as additional candidate resources: vivo [5] (for a slot containing CSI),
  + Consider the intra-UE multiplexing when determining the target slot: DoCoMo [26]
  + Based on RRC configuration, dynamically scheduled PUCCH (using *PUCCH-ResourceSet*) can be used: CAICT [29]
* **First available slot defined by PUCCH of *sps-PUCCH-AN-List-r16* or *n1PUCCH-AN* (1):** CATT [9]
  + Details:
    - *Initial SPS PUCCH resource defines validity in the target slot - i.e. only deferred payload defining the target slot (i.e. before any multiplexing)*: CATT [7]
* **Reuse the same condition as for the initial slot (2):** Samsung [8] (i.e. Alt. 2), LGE [18] (i.e. Alt. 1A)
  + Next SPS PUCCH occasion of the SPS configuration: LGE [18] (FFS if possible for a different SPS configuration)
* **New PUCCH resources defined for deferred HARQ-ACK (1):** CAICT [29] (consider)
* **Additional input on the PUCCH resource selection in the target slot & target slot determination:** 
  + If the total payload size of deferred SPS HARQ and ‘non-deferred’ SPS HARQ-ACK cannot be accommodated in the target slot, nothing is transmitted and a new target slot for all SPS HARQ is determined: Huawei/HiSi [1], Qualcomm [16]
  + Flexible symbols valid for PUCCH of deferred HARQ-ACK transmission: ZTE [6], TCL [25] (semi-static FS)
  + The size of the deferred HARQ-ACK codebook is within the UCI size range configured for the selected PUCCH: ZTE [6]
  + The number of the selected PUCCH symbols is not less than the number of original PUCCH symbols to ensure coverage: ZTE [6]
  + The selected PUCCH has the earliest end symbol: ZTE [6]
  + Further deferral if certain conditions not satisfied: ZTE [6]
  + Target slot for SPS HARQ-ACK deferral is not changed after determination: CATT [9]
  + PUCCH resource in the target slot determined based on the total HARQ payload size (SPS defer, SPS new, DG HARQ): CATT [9]
  + If total payload size cannot be accommodated, transmit as many SPS HARQ-ACK bits and drop the other HARQ-ACK bits: Panasonic [10] (for deferred HARQ-ACK bits), OPPO [14] (transmit ‘urgent’ bits e.g. SPS HARQ not configured for deferral, and deferred HARQ-ACK bits close to the end of maximum deferral window) – **No** – Do not support partial deferral: Look for another target slot which can accommodate all deferred A/N bits: Qualcomm [16]
  + If the payload/ code rate on a PUCCH resource is larger than a payload/ code rate threshold, the PUCCH resource is not available: China Telecom [11]
  + Payload size determined by deferred and non-deferred SPS HARQ-Ack bits in a slot: FGI/APT [15]
  + If the selected PUCCH carrying deferred A/N bits overlaps with DL transmission-scheduled by DCI in the target slot or DL/flexible symbol indicated by DCI format 2\_0, UE drops the deferred A/N bits without their further deferral: Qualcomm [15]

**Codebook construction / multiplexing in the target slot of deferred and non-deferred HARQ-ACK:**

* **Option 1: Same handling for all HARQ-ACK conditions (SPS only, Type 1 CB, Type 2 CB) (5):** 
  + **Deferred SPS HARQ-ACK bits are appended to the initial HARQ-ACK bits / CB in the target slot:** Nokia/NSB [3] (for simplicity due to same handling for all cases), CATT [9] (FFS Type 1 CB optimizations), Lenovo/Motorola [13], DoCoMo [26]
  + **Concatenation of individual deferred CB(s) in order of time to the initial HARQ-ACK bits / CB:** Qualcomm [16](more than one deferred HARQ-ACK codebook can be deferred to the same PUCCH)
* **Option 2: Specific handling for different HARQ-ACK cases (SPS only, Type 1 CB, Type 2 CB) (6-7?):**
  + **SPS only CB (new & deferred)**:
    - Alt. 1: Rel-16 rules to be applied: Huawei/HiSi[1], vivo [2], Sony [7], Intel [21]
    - Alt. 2: Deferred SPS HARQ-ACK bits amended to new, initial HARQ-ACK bits: ZTE [6],
  + **Type 1 CB**:
    - Alt. 1: Map deferred SPS HARQ-ACK bits with k1+ k1def included in the K1 setto the Type 1 HARQ-ACK codebook, other SPS HARQ-ACK bits are appended: Huawei/HiSi [1], vivo [2], Ericsson [4] (?), ZTE [6], NEC [12]
    - Alt. 2: K1 set is extended by k1+k1def for Type 1 CB construction: vivo [2], LGE [18] (?, union of k1 sets), Intel [21]
    - Alt. 3: Pre-pend the deferred SPS HARQ-ACK to the Type 1 CB: ETRI [19]
  + **Type 2 CB**:
    - Alt. 1: Rel-16 rules to be applied: Huawei/HiSi [1], vivo [2], Sony [7], Intel [21]
    - Alt. 2: Deferred SPS HARQ-ACK bits amended to new, initial HARQ-ACK bits: ZTE [6]
    - FFS: ETRI [19]
* **In addition:**
  + The entire HARQ-ACK codebook containing at least one SPS HARQ-ACK for deferral is deferred (and not just the SPS HARQ-ACK bits to be deferred, but other SPS HARQ or DG PDSCH HARQ): Qualcomm [16]

**HARQ process collision:**

* **Do NOT confirm the RAN1#105-e working assumption, the deferred SPS HARQ-ACK can still be transmitted:** Sony [7]
* **Confirm the WA with the following update:** Samsung [8] (…to only allow SPS HARQ collision, but prevent collisions for DG PDSCH HARQ)
  + *In case the UE ~~receives~~ is configured to receive a PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.*
* **Confirm the working assumption with an update to clarify that ‘received PDSCH’ is skipped and non-skipped SPS PDSCH:** Intel [21]
* **Confirm the WA on HARQ process collision:** LGE [18],
* **Change to HARQ buffer operation for HARQ process collision - drop the successfully decoded PDSCH soft-bits:** Sony [7]

**Other / misc:**

* Qualcomm [16]: Upon joint configuration of any combination of “SPS PUCCH HARQ deferral to 1st available PUCCH resource”, “PUCCH carrier switching” and “1-shot Enhanced Type 3 CB HARQ”, execution of “SPS PUCCH HARQ deferral to 1st available PUCCH resource” starts immediately after the SPS PUCCH HARQ deferral triggering and it stops:
  + When appropriate PUCCH resource for the transmission of deferred HARQ is found, or
  + When a request for “1-shot Enhanced Type 3 CB” is received, or
  + When a “PUCCH-carrier switch command” is received in DCI (in case of more than 1 PUCCH CCs)
  + When the maximum value of “k1\_def” is reached
* Change the definition of k1def by only counting UL and special slots: Xiaomi [27]
  1. 1st Round of email discusssions

During the 1st GTW session, the following was agreed:

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| **Agreement**  The SPS HARQ-ACK deferral is enabled per SPS configuration   * Note: part of sps-config, only HARQ-ACK of SPS PDSCH configurations enabled for deferral is in principle subject to deferral   Agreement  Definition of when to defer from the initial slot:   * Alt1: Deferral only, if the SPS HARQ-ACK in the initial slot/sub-slot cannot be transmitted as the resulting PUCCH resource for transmission using the PUCCH by SPS-PUCCH-AN-List-r16 or n1PUCCH-AN is not valid |

**Maximum deferral value of k1+k1def**

On the maximum deferral, the opinions seem to be slightly split (5 vs 6) between the maximum k1 value and RRC configuration. Moreover, some further clarifications would still be needed for both methods:

* For the maximum k1 value, is the maximum k1value given by the maximum across all configured K1 sets (incl. DCI format 1\_2 specific, LP/HP K1 sets) or is the maximum k1 value determined based on the applicable K1 set of the activation DCI (i.e. DCI format specific, LP/HP K1 sets)
* For the RRC configuration, is there a single max. deferral value applicable for all SPS configurations applicable for deferral, or is the value configurable per SPS configuration.

One company suggesting that there is no need to define a maximum deferral in terms of k1+k1def,but this would be against the earlier RAN1 agreement. Moreover, 3 companies think the deferral should be limited to existing k1 values in the K1 set in addition, but also here, based on earlier agreement to only discuss a limit on the minimum and maximum deferral.

Therefore, the following question is brought forward. **Please add your companies name directly to the Alternatives in the question and provide your additional comments or alternatives in the table below.**

**Question 2.1: The maximum deferral value in terms of k1+k1def is determinedas:**

* **Alt. 1: Maximum k1 value across all configured K1 sets / dl-DataToUL-ACK sets**
  + *Note: this includes different PUCCH configurations, and DCI format specific configurations*
  + **Supporting companies: Ericsson,** …
* **Alt. 2: Maximum k1 value of the K1 / dl-DataToUL-ACK set applied for the SPS activation**
  + *Note: set is chosen based on the PHY priority and activating DCI format*
  + **Supporting companies: OPPO, vivo, ZTE,TCL, NEC, CATT (1st preference), LG, Huawei**…
* **Alt. 3: by RRC configuration of a single maximum value applicable to all SPS processes** 
  + *Note: SPS configuration specific max. deferral value not supported*
  + **Supporting companies: Ericsson, Lenovo/Motorola Mobility** …
* **Alt. 4: by RRC configuration per SPS configuration**
  + *Note: SPS configuration specific max. deferral value supported*
  + **Supporting companies: Nokia/NSB, Panasonic, Sony, Intel, Sharp, DOCOMO, Samsung, Spreadtrum, ETRI, Qualcomm, NEC, CATT (2nd preference), China Telecom, FGI/APT, Lenovo/Motorola Mobility** …
* **Alt. 5: Other**
  + **Supporting companies:** …

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| *Company* | *Comments or Alt. 5 – other options* |
| Nokia/NSB | Alt. 4, as this allows to take into account different latency constraints for different SPS configurations. |
| OPPO | Alt.2.  In addition, we want to clarify whether the maximum deferral value takes effect into PUCCH repetition for SPS HARQ-ACK. In our understanding, there is no deferral limit for R15 PUCCH repetition. However, there is a deferral limit for SPS HARQ-ACK deferral in R17, so it’s straightforward to use the same deferral limit for PUCCH repetition for SPS HARQ-ACK |
| vivo | Alt. 2. Note the SPS HARQ-ACK has corresponding priority when two priorities are configured. So the maximum k1 value for corresponding priority should be applied.  Alt.2 is beneficial for Type 1 CB construction and smaller RRC overhead. |
| Panasonic | We share the same view as Nokia. |
| Ericsson | Alt-1 or Alt-3  We prefer Alt-3 over Alt-4, because Alt-4 complicates operation.  With respect to Nokia’s comment, even if we have different latency constraint, there is no interest to delay intentionally more. The earlier the feedback is received, even for eMBB, the better it is.  Also, having different max values per configuration, complicates the UE behaviour to do the checking per SPS when the corresponding feedback would end up in the same slot. |
| Sony | Alt. 4. This allows each SPS to have different latency requirement. |
| Intel | Alt. 4. The different max values can provide better handling of multiplexing when multiple back-to-back SPS configuration are configured, and the gNB plans to multiplex them in the same PUCCH. |
| Sharp | Alt. 4. It is more flexible. |
| ZTE | Alt. 2. We want to clarify the maximum K1 value is selected from the set for this specific activated SPS but not for other SPS. |
| DOCOMO | Alt 4. Different latency requirements are possible for different SPS configurations. |
| Samsung | Alt. 4 is preferable as it is simpler while allowing for flexible NW operation to control deferral.  - Alt. 1/2/3 provide limited design since only one maximum k1 can be used based on K1 sets |
| Spreadtrum | Alt 4. |
| TCL | Alt.2 is preferred. To minimize the specification impact, there is no need to introduce a new parameter to indicate the maximum deferral value. It is feasible to reuse the maximum value in the configured K1 set. |
| Qualcomm | Alt 4. Maximum deferral value should be set by RRC and should be a parameter of SPS Configuration.  If for a given SPS configuration, the SPS HARQ deferral feature is activated, then the UE is given a maximum deferral value. This option provides the highest flexibility. In case SPS configuration is changing, then, the network can reconfigure the maximum deferral value as well.  The drawback with Alt 1 and Alt 2 is that one K1 value – which would have been used for defining higher flexibility in HARQ timing-is reserved now for this deferral option.  Alt 3 is too restrictive.  With regards to Ericsson’s comment, there is agreement: the goal is to transmit the feedback as soon as possible, ideally at the next sub-slot after the collision. However, in case this might not be possible, e.g. there are not enough resources in the next available UL sub-slot for this UE, e.g. the UE is granted a higher priority PUCCH or PUSCH on the same resource and the UE can not multiplex the deferred SPS HARQ bits, why would the UE be penalized in not being able to defer its HARQ bits, as long as the DL packet does not expire? |
| NEC | Alt.2 or Alt.4. Alt.4 is flexible to satisfy different latency requirements. Alt.2 is simple and doesn’t need additional RRC signalling. |
| China Telecom | We support Alt.4. We have a question that can the enabling/disabling of SPS HARQ-ACK deferral per SPS configuration be implicitly determined by the maximum deferral value configuration, i.e. whether the configured maximum deferral k1+k1defequals to k1 of the same SPS? |
| FGI/APT | Alt. 4. Different SPS configuration can have different latency requirement. |
| LG | We support Alt. 2. For maximum deferral, we think flexibility is not important. |
| Huawei | Alt.2. As the SPS configurations associated with the URLLC service can be configured with a high priority PUCCH-config, in which the maximum k1 value in the K1 set can represent the maximum postpone time. Thus there is no strong need to additionally configure a dedicated maximum deferring value. |
| Lenovo, Motorola Mobility | Alt. 4 or Alt 3. Similar to configuring HARQ-ACK deferral per SPS configuration, the max deferral value can be configured per SPS configuration, considering different target traffics for different SPS configurations. For simplicity, Alt 3 is also acceptable. |

**HARQ process collision:**

There had been mixed input on the RAN1#104bis-e working assumption. One company suggests to confirm the working assumption as is, two companies suggest minor modifications to the working assumption and one company thinks the working assumptions should not be confirmed, as the UE could at least store the HARQ-ACK information even though there would be ‘new DL-SCH data’ being received for that HARQ process (see discussions by Sony in [7]).

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| Working assumption: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:   * In case the UE receives PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped. |

The motivation by the two companies for a small change to the working assumption coming from the following facts:

* Samsung [8] discusses, that the OoO rule /collision should be limited to SPS PDSCH only but not apply to HARQ of DG PDSCH which should be avoided by gNB implementation.
  + *In case the UE ~~receives~~ is configured to receive a PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.*
* Intel [21] discusses, that the ‘received’ may include skipped and non-skipped SPS PDSCH. One option here could be go to with the formulation suggested by Samsung, or alternatively (to not limit this to SPS PDSCH only) something like this could be done:
  + *In case the UE is expected to receive~~s~~ PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.*

Let’s gather company input here, based one the following alternatives. **Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below.**

**Question 2.2: With respect to the RAN1#104bis-e WA on the HARQ process collision handling for SPS deferral:**

* **Alt. 1: Confirm the WA without changes**
  + **Supporting companies: Nokia/NSB, OPPO, vivo (2nd), Panasonic, Sharp, ZTE, DOCOMO, Spreadtrum, TCL (2nd), Qualcomm (2nd), ETRI, China Telecom, FGI/APT, LG, Lenovo/Motorola Mobility, Ericsson** …
* **Alt. 2: Confirm the WA with the following changes:**
  + *In case the UE ~~receives~~ is configured to receive a PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.*
  + **Supporting companies: Intel, Samsung,** …
* **Alt. 3: Confirm the WA with the following changes:**
  + *In case the UE is expected to receive~~s~~ PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.*
  + **Supporting companies: Nokia/NSB, OPPO, vivo (1st preference), Panasonic, Intel, Sharp, ZTE, Spreadtrum, TCL (1st) , Qualcomm (1st) , NEC, ETRI, China Telecom, FGI/APT, LG, Huawei, Lenovo/Motorola Mobility, Ericsson,** …
* **Alt. 4: Do not confirm the WA. The UE drops the deferred SPS HARQ bits if the PDSCH for that SPS is successfully decoded**
  + **Supporting companies: Sony** …
* **Alt. 5: Other**
  + **Supporting companies: CATT (see comments in the table)**…

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| *Company* | *Comments or Alt. 5 – other options* |
| Nokia/NSB | Alt. 1 or Alt. 3 For Alt. 2: we think there could be also collision with dynamically scheduled PDSCH Alt. 4: we don’t think that such operation is feasible |
| OPPO | Alt 1 and Alt 3, Alt 3 is more accurate. |
| vivo | Slightly prefer Alt.3. We are also OK with Alt.1.  Regarding Alt. 2, gNB may intentionally discard the deferred SPS HARQ-ACK by scheduling a new dynamic PDSCH for the corresponding HARQ process ID if the deferred SPS HARQ-ACK is no longer valuable, or there is no other available HARQ process. |
| Panasonic | Alt. 1 or Alt. 3 |
| Sony | Modified Alt. 4:  I think our proposal was misunderstood (in the original Alt. 4). We proposed that whether to drop the defer SPS HARQ bits or the non-defer SPS HARQ bits depends on whether the defer SPS PDSCH was successfully decoded. If the defer SPS’s PDSCH was not successfully decoded then it would need retransmission and it is not beneficial to blindly drop it. On the other hand, if the defer SPS’s PDSCH was successfully decoded then there is no point storing the soft bits in the HARQ buffer and might as well drop it. |
| Intel | Alt. 2 or Alt. 3. As we mentioned, Alt.1 has some ambiguity when SPS PDSCH is not transmitted (and thus is not received) |
| Sharp | Alt. 1 or Alt. 3 |
| ZTE | Agree with Nokia, Alt. 1 or Alt. 3 |
| DOCOMO | Alt 1.  The rule can be applied for HARQ process ID collision with dynamic PDSCH and SPS PDSCH. |
| Samsung | Alt. 2.  Collision by dynamic scheduling can be avoided by gNB considering k1\_def, or by using another HARQ process number – there is no shortage of HPNs. |
| Spreadtrum | Alt. 1 or Alt. 3 |
| TCL | Alt.1 or Alt.3. Alt. 3 is preferred. |
| Qualcomm | Alt 1 or Alt 3. The difference between them is in the timing when the stored HARQ bit for a given SPS transmission are dropped. In the case of Alt 3, the UE drops them by receiving DCI with the HARQ Process indication. In the case of Alt 1, the drop the stored deferred SPS HARQ bits upon reception of the new HARQ bit in the same HARQ Process ID. Probably Alt 3 is more accurate, but Alt 1 is also fine. |
| NEC | Alt.1 or Alt.3.  Alt.1 and Alt.3 provide flexibility for gNB to discard the deferred SPS HARQ-ACK. |
| CATT | We share the same understanding on the difference between Alt. 1 and Alt. 3 as Qualcomm. But we think regardless, it will be up to UE to decide when to drop HARQ-ACK.  One general comment is that we see potential problem of misalignment between gNB and UE on the number of bits of deferred HARQ-ACK in case DCI is missed. For example, in case an SPS PDSCH occasion with same HARQ process ID as deferred SPS HARQ bit(s) is overridden by a DCI scheduling a dynamic PDSCH with a different HARQ process ID, if the scheduling DCI is missed at the UE side, UE would drop the deferred SPS HARQ bit(s) for the HARQ process ID while gNB has a different understanding. Another example is that if UE is scheduled to receive a PDSCH with the same HARQ process ID as the deferred SPS HARQ bit(s) and the scheduling DCI is missed, UE does not drop the deferred SPS HARQ bit(s) for the HARQ process ID while gNB has a different understanding. We would like to hear companies’ views on that. |
| China Telecom | Alt. 1 or Alt. 3. For Alt. 4, what is the UE behaviour if both the deferred and non-deferred SPSs need retransmission? |
| FGI/APT | Alt. 1 or Alt. 3 |
| LG | Alt. 1 or Alt. 3 |
| Huawei | Alt.3 is more accurate. As the SPS PDSCH skipping is removed from the scope, Alt.1 is actually the same meaning with Alt.3 assuming the PDSCH in Alt.1 implies SPS PDSCH. |
| Lenovo, Motorola Mobility | Alt 1 or Alt 3 |
| Ericsson | Alt 1 or Alt 3 |

**Target slot definition:**

Now that we defined the handling in the initial slot, we can also focus more on the target slot determination. There are plenty of different proposals on restrictions / conditions by different companies – well, let’s first try with the following set of questions here:

**Question 2.3: Definition of next available PUCCH for inter-slot/sub-slot deferral (i.e. target slot),**

* **Alt. 1: The earlier of *sps-PUCCH-AN-List-r16* or  *n1PUCCH-AN,* or a dynamically indicated PUCCH resource *(from PUCCH-ResourceSet*)**
  + *Moderator comment / understanding: This is somehow aligned with the handling in the initial slot*
  + **Alt. 1 (without further down-selection, i.e. Alt. 1A or Alt. 1B): OPPO, Sony, TCL**
  + **Alt. 1A: the target cell definition takes the HARQ-ACK multiplexing in the target slot into account** 
    - **Supporting companies: Nokia/NSB, vivo, Panasonic, Intel, Sharp, ZTE, DOCOMO, Samsung, ETRI, CATT, China Telecom, FGI/APT, Huawei, Lenovo/Motorola Mobility** …
  + **Alt. 1B: the target cell does not takes the HARQ-ACK multiplexing in the target slot into account (i.e. target slot determination based only on deferred SPS HARQ-ACK bits)**
    - **Supporting companies:** …
* **Alt. 2: the First available slot defined by PUCCH of *sps-PUCCH-AN-List-r16* or *n1PUCCH-AN*** 
  + **Alt. 2A: the target cell definition takes the SPS HARQ-ACK multiplexing (deferred / non-deferred) in the target slot into account** 
    - **Supporting companies: LG,** …
  + **Alt. 2B: the target cell does not takes the HARQ-ACK multiplexing in the target slot into account (i.e. target slot determination based only on deferred SPS HARQ-ACK bits)**
    - **Supporting companies:** …
* **Alt. 3: New PUCCH resources defined for deferred HARQ-ACK** 
  + **Alt. 3A: the target cell definition takes the SPS HARQ-ACK multiplexing (deferred / non-deferred) in the target slot into account** 
    - **Supporting companies:** …
  + **Alt. 3B: the target cell does not takes the HARQ-ACK multiplexing in the target slot into account (i.e. target slot determination based only on deferred SPS HARQ-ACK bits)**
    - **Supporting companies:** …
* **Alt. 4: Other**
  + **Supporting companies:** …

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| *Company* | *Comments or Alt. 4 – other options* |
| Nokia/NSB | Alt. 1A, as this is first of all aligned with the initial slot handling and should take the HARQ multiplexing into account (to prevent overall dropping of e.g. SPS HARQ-ACK) |
| OPPO | Alt 1.  Before we go to Alt x.A and Alt x.B, we’d better to discuss PUCCH carrier switching in section 6 clearly. In principle, we prefer to that SPS HARQ-ACK defer and PUCCH carrier switching should be decoupled. In addition, for UE not supporting PUCCH carrier switching, it is not necessary to select Alt.x A and Alt. xB. |
| vivo | Alt.1A, we share Nokia’s views.  One comment is for Alt.1B, we think Alt.1 precldue Alt.1B by its description of “**or a dynamically indicated PUCCH resource *(from PUCCH-ResourceSet*)**” |
| Sony | Alt. 1.  Should we decide the target slot definition first before venturing into multi carrier operation? |
| Intel | Align with the initial slot handling for clean logic. In our understanding this is Alt.1a |
| Sharp | Alt. 1A. We share the same view with Nokia. |
| ZTE | Alt. 1A, from our perspective, UE should determine a PUCCH in target cell, the PUCCH may include PUCCH resources for SPS and DG PUCCH, and then if the determined PUCCH overlaps with other PUCCHs, multiplexing is allowed. |
| DOCOMO | Alt 1A. Alignment for behavior in initial slot and deferral slot is expected. |
| Samsung | Alt. 1A  RAN1 previously focused on the PUCCH resources checking deferral. HARQ-ACK can also be multiplexed in PUSCH following Rel-16. UE should first perform multiplexing (Step 1) and then check DL conflicts (Step 2) based on the following agreement. If HARQ-ACK can be transmitted in a PUSCH, deferral should be avoided (also considering the latency requirement for URLLC).  **Agreement**  To address collision with semi-static DL symbols and SSB, the following easy way is suggested:   * Step1: Perform intra UE prioritization (including multiplexing, overriding) according to related working assumption in 102 e-meeting and produce final PUCCHs/PUSCHs. * Step 2: Final PUCCHs/PUSCHs is cancelled by semi-static DL symbols and SSB symbols.   We would also like to have further discussion when deferring HARQ is multiplexed into DG-PUSCH or CG-PUSCH for determining initial or target slot. |
| TCL | Regarding the 4 alternatives above, we support Alt. 1.  As for whether to take multiplexing in the target slot into account, we share the same view as Sony. |
| Qualcomm | What is the motivation of this question?  Is it to define the list among the available to the UE PUCCH resource lists (*sps-PUCCH-AN-List-r16* or  *n1PUCCH-AN,* or *PUCCH-ResourceSet, or multi-CSI-PUCCH-ResourceList* and *pucch-CSI-ResourceList*) from which the UE will pick the PUCCH resource to transmit?  If this is the case, it would be useful to clarify some cases in the question. In the “target” sub-slot after SPS HARQ collision there are the following cases:   1. No new UCI payload is present, hence only *sps-PUCCH-AN-List-r16* or  *n1PUCCH-AN* are available. 2. New SPS HARQ is present, hence only *sps-PUCCH-AN-List-r16* or  *n1PUCCH-AN* are available. The group has not decided yet if multiplexing of new SPS HARQ bits and deferred SPS HARQ bits is allowed. 3. New HARQ bits corresponding to dedicated grant PDSCH transmission are present. Hence, *sps-PUCCH-AN-List-r16* or  *n1PUCCH-AN* and *PUCCH-ResourceSet* are available. The group has not decided yet if multiplexing of new HARQ bits and deferred SPS HARQ bits is allowed. 4. New CSI report is present. Then the UE has to choose among:  * *sps-PUCCH-AN-List-r16* or  *n1PUCCH-AN,* * *multi-CSI-PUCCH-ResourceList* or *pucch-CSI-ResourceList*   This is also the case if new HARQ bits for the same UE are also present in the target slot. The group has not decided yet if such multiplexing of new CSI report with deferred SPS HARQ bits is allowed in the target slot.  It would have been more appropriate to decide the multiplexing options in the target slot, before answering this question here. The group has been spending several meetings in discussing the confusing options of SPS HARQ deferral triggering and this should be avoided here again.  At least, the group can address the cases i) and ii) above in which only *sps-PUCCH-AN-List-r16* or  *n1PUCCH-AN* are available and start discussion on the multiplexing options at the target slot in a new thread.  What does option 3 mean? The network configures a secondary *sps-PUCCH-AN-List-r16* for example and this list is going to be used only in cases of SPS HARQ deferral?  With the current formulation of the questions, support for Alt 1 and Alt 2 based on the current understanding. Interested to expl  Suggestions:   * is it possible to remove the options 1A, 2A, 3A from the discussion now? Hence, start defining the cases in which no HARQ multiplexing is taken into account. * Can the sentence “or a dynamically indicated PUCCH resource *(from PUCCH-ResourceSet*)” be removed from Option 1? Option 1 and 2 then become identical, correct? * Focus on single carrier case (as Sony suggested) for now   Moderator comment:   * First, I don’t think we can start discussing this overall early enough * As several companies discussed the multiplexing of deferred SPS HARQ-ACK with CSI in the target slot (SPS HARQ-ACK, DG PDSCH HARQ, CSI), I guess the overall assumption would be to support this. Details on the multiplexing are discussed below – so don’t see why not discussing this on parallel. If needed, we can try to make a related agreement on this * Agree on (i) to (iv), at least this had been my implicit assumption there that in case multiplexing is supported, we don’t change the PUCCH resource determination compard to Rel-15 (… and if not agreed otherwise, this should automatically apply, we don’t need to agree for each thing we are not changing).   Reply to moderator:   * Then, the assumption is that deferred SPS HARQ-ACK can be multiplexed according to cases ii) to iv) above. Then, the whole question is for the case in which the there is new UCI in the target slot. Then, options A & B differ in the fact that in the presence of a new PUCCH resource list (*sps-PUCCH-AN-List-r16* or  *n1PUCCH-AN, multi-CSI-PUCCH-ResourceList* or *pucch-CSI-ResourceList*), the UE should consider the new additional to *sps-PUCCH-AN-List-r16* list or not. Can you confirm this understanding? If yes, then Alt 1 and Alt 2 differ only in the presence of “**dynamically indicated PUCCH resource *(from PUCCH-ResourceSet*)**”. It seems that they are two different cases: with new UCI (Alt 1) and without UCI (Alt 2). If this understanding is correct, then, * Why not having the case in which the deferred SPS HARQ can be multiplexed with new CSI? * Choosing between different cases does not seem to be appropriate.  An effort in clarifying/rephrasing the question now would help the group in converging faster. |
| NEC | We are not very clear of Alt.1. In our understanding, if there is a PUCCH resource dynamic indicated for DG HARQ-ACK on the target slot, then deferred SPS HARQ-ACK and DG HARQ-ACK should be multiplexed on the dynamic indicated PUCCH resource rather than the earliest one among *sps-PUCCH-AN-List-r16* and thedynamic indicated PUCCH resource.  So Alt.1 means that if UE is configured with both *sps-PUCCH-AN-List-r16* and *PUCCH-ResourceSet* for DG HARQ-ACK*,* UE will determine an earliest available PUCCH resource from the two set as the target PUCCH resource even no DG HARQ-ACK is indicated in the target slot? |
| CATT | Alt. 1A, same handling as in the initial slot. |
| China Telecom | Alt. 1A. The same handling as initial slot/sub-slot. |
| FGI/APT | Alt. 1A. SPS HARQ-ACK should not be dropped when PUCCH resource configured by sps-PUCCH-AN-List-r16 or n1PUCCH-AN is invalid and can be multiplexed in a valid PUCCH resource configured by PUCCH-ResourceSet. |
| LG | Support Alt. 2A.  It is not clear to us how UE works with Alt. 1. Does we need to define timeline for gathering DCI of dynamically indicated PUCCH?  To align with initial slot handling, we suggest to use Alt. 2 for determine “target slot” and use Alt. 1A for determine “target PUCCH”. |
| Huawei | Alt.1A. As we already have agreement on the initial slot, we think the candidate target slot should be aligned with the initial slot. |
| Lenovo/Motorola Mobility | Alt 1A. Agree with Vivo’s comment (Alt 1B is not a part of Alt 1) |
| Ericsson | Although we understand moderator’s intentions based on the additional explanation, but it is not clear why we need to define this. The same condition for deferral from initial slot can be reused. The only thing needed is when checking deferral condition, multiplexing with other A/N in a slot can be considered.  The target slot is known when after checking the condition, there is no deferral in that slot. If the condition for deferral is still met in the slot, then it is deferred further to the next slot and the condition for deferral is considered again for that slot, and so on, until the deferred SPS HARQ-ACK reaches the max limit.  Moreover, we agree with QC that despite the intention, the main bullet of Alt 1 is read as we are defining a rule how to pick a PUCCH resource (it says “earlier”) among those listed in the bullet. |

**Question 2.4: If after determination of a target slot, the deferred SPS HARQ-ACK cannot be transmitted (e.g. due to SFI indication or similar),**

* **Alt. 1: the deferred SPS HARQ-ACK bits are not further deferred and are dropped**
  + **Supporting companies: Nokia/NSB, OPPO, vivo, Panasonic, Intel, Sharp, DOCOMO, CATT, China telecom, NEC, Huawei, Ericsson** …
* **Alt. 2: the deferred SPS HARQ-ACK bits are further deferred (i.e. new target slot is determined)**
  + **Supporting companies:** …
* **Alt. 3: Other**
  + **Supporting companies:** …

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| *Company* | *Comments or Alt. 3 – other options* |
| Nokia/NSB | Alt. 1 for simplicity. We don’t think we should over-optimize the operation here, as in the worst case re-transmission of cancelled HARQ can be applied as well. |
| OPPO | Alt. 1 for simplicity. |
| vivo | We support Alt.1. Share Nokia’s views for simplicity and re-Tx of dropped HARQ-ACK can be used as complement. |
| Sony | This seems to contradict the definition of target slot. If the PUCCH in the target slot is not available how can it even be called target slot in the first place?  Moderator: please note, that the target slot determination takes only collisions with defined invalid symbols into account. There could be still SFI or dynamically scheduled PDSCH preventing PUCCH to be transmitted on flexible symbols. If SFI is not configured, without a dynamic scheduling DCI for the PUCCH the PUCCH would not be transmitted either. We should follow the procedures described in Sec. 11 of 38.213. |
| Intel | Alt.1. Such dropping can be further restored by HARQ-ACK retransmission |
| Sharp | Alt. 1 for simplicity. |
| ZTE | I think this issue is not valid. From the previous agreement, the symbols collide with semi-static DL symbols, SSB and CORESET#0 is regarded as ‘invalid’. It means the flexible symbols could be the PUCCH resources in target slot for deferral. Then it is not expected that the dynamic SFI could change the flexible symbols for PUCCH to DL symbols.  Agreements: For SPS HARQ-ACK deferral, for the determination of valid symbols in the target slot/sub-slot a collision with semi-static DL symbols, SSB and CORESET#0 is regarded as ‘invalid’ or ‘no symbols for UL transmission’.  Moderator: please note, that the target slot determination takes only collisions with defined invalid symbols into account. There could be still SFI or dynamically scheduled PDSCH preventing PUCCH to be transmitted on flexible symbols. If SFI is not configured, without a dynamic scheduling DCI for the PUCCH the PUCCH would not be transmitted either. We should follow the procedures described in Sec. 11 of 38.213. |
| DOCOMO | Alt 1 for simplicity. |
| Samsung | Alt. 1. This is aligned with previous agreement that SPS HARQ deferring only considers semi-static configuration (TDD, SSB). |
| Qualcomm | We also support simplicity. The question needs to be clarified. For which cases, the UE cannot be transmitted?  Is it due to SFI, as mentioned? And what if the SFI is missed? Is allocation of SPS HARQ on dynamically configured flexible symbols allowed? Has the group decided on this? Is the transmission of deferred SPS HARQ bits on dynamically configured flexible symbols allowed?  By the way, in R1-2017336, the problem when SPS HARQ is configured on dynamic flexible symbols is mentioned. It is presented here as well.    The only case in which dropping of deferred SPS HARQ bits is justified is the case in which there are new HARQ bits corresponding to a DG PDSCH and the network does not provide a PUCCH resource in the *PUCCH-ResourceSet,* that accounts for deferred SPS HARQ bits. This is a clear indication that it is not a priority for the network to get as soon as possible the deferred SPS HARQ bits.  Support for Alt 1-only for the case in which the deferred SPS HARQ bits cannot be multiplexed with new UCI bits.  Suggestion: start the discussion on the use of dynamically configured flexible symbols as “initial” sub-slot or “target” sub-slot.  Moderator reply: Please note, that in the target slot we decided when the UE is allowed to defer the bits (i.e. if there is a collision with defined invalid symbols) and the PUCCH cannot be transmitted. The handling of when a PUCCH transmission in principle is allowed (in terms of SFI handling, FS), is defined in the specs already. No need to agree this here again.  The same could apply the target slot determination, we have a certain rule to determine the target slot – if target slot is determined, if the PUCCH can be transmitted in the end (based e.g. SFI handling) again is based on the current specification handling.  QC’s Reply to moderator  Difference in understanding of “initial slot” and “target slot”.  “Initial slot”: slot in which SPS HARQ collision with DL occurs  “Target slot”: any slot after the “initial slot” in which the UE can try to transmit the collided HARQ bits.  Hence, according to understanding what is described here : (“that in the target slot we decided when the UE is allowed to defer the bits (i.e. if there is a collision with defined invalid symbols) and the PUCCH cannot be transmitted.”)  Is “initial slot” and not “target slot”.  The goal with the point above is of course not to decide if PUCCH is going to be transmitted on flexible symbols.  The goal is that the group decides if   1. SPS deferral should be configured when SPS PUCCH is transmitted on dynamically indicated flexible symbols.   Whether dynamic flexible symbols can be “target slot”. The case above in the figure is valid and it results in the network behaving as SPS HARQ deferral has never existed. |
| ETRI | We tend to agree with Sony, if only SPS HARQ is present. The dropping condition at the target slot may be the same as the initial slot. |
| NEC | Alt. 1 for simplicity. |
| China Telecom | Alt. 1 for simplicity. |
| FGI/APT | Alt. 1 if SFI indication is taken into account when determining the target slot. Otherwise, Alt. 2. Since semi-static flexible symbols are valid symbols for the PUCCH resource for deferral, if SFI indication is not taken into account when determining the target slot, unnecessary dropping due to collision with SFI indicated DL symbols may happen.  Moderator: please note, that the target slot determination takes only collisions with defined invalid symbols into account. There could be still SFI or dynamically scheduled PDSCH preventing PUCCH to be transmitted on flexible symbols. If SFI is not configured, without a dynamic scheduling DCI for the PUCCH the PUCCH would not be transmitted either. We should follow the procedures described in Sec. 11 of 38.213. |
| LG | Alt. 1 for simplicity |
| Huawei | We are fine with Alt.1 |
| Lenovo, Motorola Mobility | If PUCCH transmission determined by *sps-PUCCH-AN-List-r16* or *n1PUCCH-AN* in a slot/sub-slot is cancelled due to SFI, UE can further defer as long as HARQ-ACK feedback delay is less than the max delay determined based on the max deferral value. If PUCCH transmission in a slot is determined by DCI, cancellation of transmission due to SFI is not expected. In case that UE has to cancel PUCCH transmission due to other reasons, e.g. UL cancellation indication, intra-UE multiplexing, UE has to drop HARQ-ACK. |
| Ericsson | To clarify the intention of the proposal, our understanding is as follows.  First of all, if the target slot is found, it means that SPS HARQ-ACK can be transmitted in that target slot.  If it is about having SFI changing some F symbols to D symbols, causing deferral, then our view is to simply drop the SPS HARQ-ACK. That is, SFI cannot cause SPS HARQ-ACK deferral. The question should be clarified.  Based on moderator’s clarification. It seems our understanding is aligned with Alt 1. If this interpretation is correct, we support Alt 1.  Moderator: Please note, that the target slot determination takes only collisions with defined invalid symbols into account. There could be still SFI or dynamically scheduled PDSCH preventing PUCCH to be transmitted on flexible symbols. If SFI is not configured, without a dynamic scheduling DCI for the PUCCH the PUCCH would not be transmitted either. We should follow the procedures described in Sec. 11 of 38.213. |

**Question 2.5: In case the total payload size of deferred HARQ-ACK cannot be accommodated in the determined target slot, the following is applied:**

* **Alt. 1: No SPS HARQ-ACK is transmitted, deferred and non-deferred HARQ-ACK bits are not transmitted and a new target slot is determined**
  + **Supporting companies: Intel, DOCOMO, ETRI, China Telecom, Huawei**…
* **Alt. 2: partial deferral, i.e. only part of the deferred HARQ-ACK bits (that can be mapped) is transmitted**
  + **FFS: handling of other bits, drop other deferred HARQ bits or even drop non-deferred SPS HARQ-ACK bits (as not ‘urgent’)**
  + **Supporting companies: OPPO, Panasonic, Sony, TCL , China Telecom, FGI/APT,** …
* **Alt. 3: SPS HARQ-ACK is dropped (and not further deferred)**
  + **Supporting companies: Nokia/NSB, Sharp, Qualcomm, FGI/APT, LG,** …
* **Alt. 4: Other - no handling needed (this is up to gNB):** 
  + **Supporting companies: vivo, ZTE, DOCOMO, Samsung, NEC, CATT,** …

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| *Company* | *Comments or Alt. 4 – other options* |
| Nokia/NSB | Alt. 3 for simplicity. We don’t think we should over-optimize the operation here, as in the worst case re-transmission of cancelled HARQ can be applied as well.  Alt. 1 leads to unnecessary SPS HARQ-ACK deferral of new/initial SPS HARQ  Alt. 2: complicated specification operation |
| OPPO | “Target slot” in main bullet is not clear for us. Is it a next slot after deferral or final slot (e.g. the last slot satisfying maximum defer value) ?  If it is a next slot after deferral, Alt3 is unreasonable. Because there is an opportunity to defer and find an available PUCCH in further slot.  If it is final slot, Alt 1 is unreasonable. It should stop defer when maximum defer value is achieved.  Alt 2 transmits SPS HARQ-ACK as soon as possible, it is aligned with intention of initial slot determination, i.e. multiplexing before defer. |
| vivo | For this “issue”, we think the case that the total payload size of deferred HARQ-ACK cannot be accommodated in the determined target slot is rare or can be avoided by gNB proper configuration. If the total payload includes the HARQ-ACK for dynamic PDSCH, the payloads for the last PUCCH set is set as 1706 bits; If the total payload only includes the HARQ-ACK for SPS PDSCH, gNB should have proper configuration on the payload size for the PUCCH resource taking SPS deferral into account. |
| Panasonic | Alt. 2, the partial transmissions of deferred HARQ-ACK could reduce the latency and avoid HARQ-ACK dropping. |
| Sony | Alt. 2 seems sensible choice since there are still deferred HARQ-ACK bits that can be transmitted. |
| Intel | Support Alt.1 which converges with deferral conditions for initial slot/sub-slot and target slot/sub-slot.  Alt.2 makes it too complicated. Alt.3 may be acceptable, but it is unclear how to differentiate such case with the case when the bits could not be mapped to a valid slot/sub-slot. |
| Sharp | Alt. 3 for simplicity. |
| ZTE | The issue is not valid. From my understanding, when UE determines the PUCCH resource in target slot, it should consider there is sufficient resources for the total payload size. As mentioned in previous question, the multiplexing with other PUCCHs should also be considered when determining the target slot. |
| DOCOMO | We don’t think such a slot where determined PUCCH resource can’t accommodate total payload size will be determined as the target slot. It is similar to the case when the determined PUCCH resource in the slot overlaps with invalid symbol in our understanding. |
| Samsung | No optimization for this case – can be avoided by gNB scheduling. In general, prefer to avoid over-optimizations that are typically counter-productive and have no real impact. |
| TCL | Alt. 2, partial deferral at least could transmit some of the SPS HARQ, and reduce the latency. |
| Qualcomm | Alt 3 for simplicity and for meaningfulness. In case the network schedules DG PDSCH and a corresponding PUCCH with the new PUCCH resource not being able to accommodate both new HARQ bits and deferred SPS HARQ bits, even when the network is aware of the existence of deferred HARQ bits, then, this is a clear indication, that the network is not in urgency in getting these deferred HARQ bits.  Alt 1 could also be supported since it provides more flexibility – with the drawback of unnecessary deferral of new HARQ bits, as mentioned by Nokia.  Alt 2 would require that the UE chooses another PUCCH resource in the *sps-PUCCH-AN-List-r16*. This means that the network should be aware of the PUCCH resource to be chosen by the UE. |
| ETRI | Alt 1 is preferred. To our understanding, this may be the condition to defer. |
| NEC | We share same view with vivo/ZTE/DCM/Samsung that this case can be avoided by gNB, optimization is not needed. |
| CATT | We agree with vivo, ZTE, DOCOMO, Samsung and NEC, the PUCCH resource in the target slot should be determined based on the total number of all deferred and non-deferred HARQ-ACK bits, gNB should avoid that the determined PUCCH resource can’t accommodate total payload size. |
| China Telecom | Alt2 or Alt 1. If the maximum defer value is not reached, it can be further deferred. If Alt 2 is considered to be too complicated, Alt 1 is also acceptable. |
| FGI/APT | Alt. 2 or Alt. 3. Only dropping part of the deferred SPS HARQ-ACK bits is preferred. Dropping all deferred SPS HARQ-ACK bits is also acceptable as this case should be avoided by proper configuration of PUCCH resources. |
| LG | We should separate ‘target slot’ and ‘target PUCCH’. For our understanding, Question 2.5 assume that UE selects target PUCCH from previously scheduled PUCCH. For re-use previously scheduled PUCCH, Alt. 3 is preferable.  If UE selects target slot having no scheduled UCI, Question 2.5 is not necessary for our understanding. |
| Huawei | Alt.1. In our understanding, a unified procedure for checking the validity of a candidate target slot/sub-slot is:   * Step 1: Multiplex all HARQ-ACKs including those originally pointed to this slot/sub-slot (non-deferred HARQ-ACK) and those deferred to this slot/sub-slot (deferred HARQ-ACK). * Step 2: Determine the PUCCH resource based on the total payload of the multiplexed HARQ-ACKs including the deferred HARQ-ACK and the non-deferred HARQ-ACK. * Step 3: Check the validity by comparing whether the available UL symbols of the current slot/sub-slot can hold the determined PUCCH. If the current slot/sub-slot can hold the multiplexed HARQ-ACKs, they are transmitted; otherwise they are further deferred to the next candidate slot.   We don’t see the above procedure has any complex issue. For Alt.2 partial dropping, it needs to revert the Step 1 to depart the multiplexed HARQ-ACK payload, which causes more complicated procedure; for Alt.3, it unnecessarily increases the probability of dropping deferred HARQ-ACK, which weakens the value of the SPS HARQ-ACK deferral feature. |
| Lenovo/Motorola Mobility | gNB can configure PUCCH resources properly such that the payload size of deferred and non-deferred HARQ-ACK is always less than the max payload size that PUCCH resources can accommodate. |
| Ericsson | Again, the question is not clear. If the target slot is found/determined, it means that deferred SPS HARQ-ACK can be transmitted.  It seems the proposal tries to address e.g., the scenario where there are many DL slots followed by one UL slot, and SPS periodicity is one slot. Then all SPS HARQ-ACK will be deferred to the UL slot. The question is what to do if SPS PUCCH resource is configured so that it cannot accommodate all deferred SPS HARQ-ACK bits. We think this can be solved by proper configuration. So Alt. 1 to Alt. 3 can be ok. Not preferred to have a fancy rule to split SPS HARQ-ACK like in Alt. 2.  Having said that, we share the same view as HW to have a unified procedure as described by three steps. |

**Codebook construction / multiplexing in the target slot of deferred and non-deferred HARQ-ACK:**

Qualcomm [16] discusses that not just the SPS HARQ-ACK applicable for deferral is deferred, but the overall HARQ-ACK codebook (incl. DG PDSCH HARQ, SPS HARQ not subject to deferral) is deferred. To clarify if only the SPS HARQ-ACK bits are subject to deferral or the overall HARQ codebook, the following question is brought forward. **Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below.**

**Question 2.6: For SPS HARQ-ACK deferral,**

* **Alt. 1: only SPS HARQ bits subject to deferral from HARQ-ACK codebook are deferred to the target slot**
  + **Supporting companies: Nokia/NSB, Panasonic, Sony, Intel, Sharp, ZTE, DOCOMO, Samsung, TCL, NEC, ETRI, FGI/APT, LG, Huawei, Lenovo/Motorola Mobility, Ericsson**…
* **Alt. 2: the entire HARQ-ACK codebook including at least one SPS HARQ-ACK bit subject to deferral is deferred to the target slot.** 
  + **Supporting companies:**…
* **Alt. 3: Other**
  + **Supporting companies:** …

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| *Company* | *Comments or Alt. 3 – other options* |
| Nokia/NSB | Alt. 1, as Alt. 2 leads to unnecessarily large payload size of the deferred codebook (e.g. for Type 1 CB when multiplexed with DG PDSCH HARQ) |
| OPPO | If SPS HARQ-ACK is multiplexed with dynamic HARQ-ACK, it is not expected that dynamic PUCCH resource carrying SPS HARQ-ACK and dynamic HARQ-ACK collides with downlink symbols. In other words, in this case, PUCCH resource carrying SPS HARQ-ACK and dynamic HARQ-ACK should transmit in current slot. |
| vivo | We would like to clarify the   1. Entire HARQ-ACK codebook above includes deferred SPS HARQ-ACK, HARQ-ACK for dynamic PDSCH and also the initial SPS HARQ-ACK? 2. What is the difference between the Question 2.6 and Question 2.7?   In case that the entire HARQ-ACK codebook includes the HARQ-ACK for dynamic PDSCH, if the codebook is dropped due to collision with another high priority channel, we think the deferred SPS HARQ-ACK and the initial SPS HARQ-ACK will be dropped, do not defer further.  In case that the entire HARQ-ACK codebook only includes the HARQ-ACK for SPS PDSCH, if the codebook is dropped due to collision with semi-static DL symbols/SSB, we think the entire HARQ-ACK codebook should defer further, i.e., Alt.2.  Moderator comment:  Difference of question 2.6 & 2.7:   * Q 2.6: This is the handling for a single HARQ-ACK codebook. Let’s for simplicity consider we have a PUCCH slot containing a HARQ-CB which is dropped based on the agreed Alt. 1 (i.e. no PHY prioritization, only collision with the defined ‘invalid’ symbols). The HARQ-ACK codebook may contain:   1. ‘new/initial’ SPS HARQ configured for deferral   2. ‘new/initial’ SPS HARQ not configured for deferral   3. Deferred HARQ-ACK   4. DG PDSCH HARQ   QC’s reply to moderator  (Since the question was triggered by our contribution). We think that the case 4 is an error case. If the scheduler allocates resources for DG PDSCH HARQ knowing that some SPS HARQ bits are deferred and even worse scheduling this (DG) PUCCH on symbols which are DL symbols, then, this is an error case. In our initial proposal, we had in mind cases 1-3.  If such a PUCCH is dropped due to the initial slot handling criteria, is only the ‘new, initial’ SPS HARQ configured for deferral (i.e. 1.) or do we defer the overall dropped HARQ-ACK codebook containing 1-4 (which for e.g. Type 1 CB, would mean the a very large deferral payload size). This is more to exclude 2. and 4. – as 3. Deferred HARQ-ACK handling is part of questions 2.4 & 2.5 above.   * Q 2.7 is about more than one dropped PUCCH / HARQ-ACK codebook. Assuming if you the condition for deferral fulfilled in slot#0 (dropped PUCCH#0) and slot #1 (dropped PUCCH#1), are the SPS HARQ-ACK bits of both slots deferred jointly to look for a target slot starting from slot #2 (i.e. looking for a target slot of the combined deferred SPS HARQ-ACK bits of PUCCH#0 and PUCCH#1), or is the UE only consider the last dropped occasion (in this case PUCCH#1) and would not defer the PUCCH#0 SPS HARQ-ACK bits (i.e. is the deferral only applicable to the last dropping, or are the dropped occasions ‘aggregated)   I hope this clarifies! |
| Sony | Alt. 1 seems to be the intention of this feature, i.e. to deferred SPS HARQ-ACK bits. |
| Intel | Alt.1 is preferred. Alt.2 contradicts the intention of the feature. |
| Sharp | Alt. 1. |
| ZTE | Alt.1. HARQ-ACK for DG PDSCH should not be deferred as we have no such agreement and this deferral is out of scope of this topic. |
| DOCOMO | Alt 1. We think Alt 1 is the motivation to enable SPS HARQ-ACK deferral per SPS configuration. |
| Samsung | Alt.1 - We don’t think that this is a general case for optimization. |
| TCL | We support Alt.1. |
| Qualcomm | Is the discussion about this proposal?  “***Proposal 1: SPS HARQ-ACK deferral to the 1st available PUCCH should be configured per SPS configuration. If a PUCCH transmission consists of HARQ-ACK for at least one SPS configuration with deferral, the PUCCH transmission is deferred to the 1st available PUCCH.***”  And the associated text?  “The feature “SPS PUCCH HARQ Deferral to the 1st available PUCCH” should be configured per SPS configuration. The reason is that different SPS configurations carry different types of traffic with different characteristics, e.g. periodicity, data rate, packet expiration time. SPS PUCCH HARQ deferral to the 1st available PUCCH implies that the PUCCH Resource ID (PRI) scheduled for the SPS PUCCH has to be reserved up to the maximum deferral time. Logically, in most cases the maximum deferral time would be associated with the DL packet expiration; in some cases, the maximum deferral time might be linked with the SPS periodicity. In some cases, reserving an unused uplink resource for a short period of time, e.g. when the maximum deferral time is e.g. 1 ms is desired. In some other cases though, when e.g. the packet expiration, or the SPS period is equal to 4 ms, reserving an unused resource for up to 4 msec might be undesirable. Or, in other cases, retransmitting a short DL packet is not as harmful, as retransmitting a large packet in the case of SPS HARQ colliding with DL symbols.  In case a given PUCCH group is consisted of two types of SPS HARQ bits, i.e.   * SPS HARQ-ACK bits configured to be deferred upon collision with DL or flexible symbols, and * SPS HARQ-ACK bits not configured to be deferred upon collision with DL or flexible symbols   then, upon collision of the PUCCH group with DL symbols, then, the whole HARQ codebook in the PUCCH group is deferred. The reason is that this option does not change the HARQ codebook and both gNB and UE are aware of the HARQ CB intended for transmission. In general, the network should try to avoid grouping SPS HARQ-ACK bits configured for deferral, with other HARQ bits not configured for deferral.”  If this is the case, then this is the proposal to defer the whole HARQ CB only if the HARQ CB is consisted of SPS HARQ bits ONLY (Alt 3).  As mentioned by Oppo, if SPS HARQ is multiplexed with HARQ bits corresponding to DG PDSCH, then, the scheduler should not do the multiplexing of SPS HARQ and new HARQ on a sub-slot, slot in which PUCCH will collide with DL symbols. The scheduler should know this.  This is our proposal 4.  ***Proposal 4: Multiplexing of DG UCI with SPS PUCCH HARQ-ACK in a PUCCH PRI which then collides with semi-static DL symbols, SSB, or CORESET#0 is handled as error case by the UE.***  Can you confirm that you were referring to Proposal 1 and its associated text? |
| NEC | We are fine for Alt.1.  But we think this case may not happen. Based on our understanding, if dynamic HARQ-ACK and SPS HARQ-ACK are multiplexed on a PUCCH resource in a slot, gNB should ensure that the PUCCH resource in the slot not collides with DL symbols, SPS HARQ-ACK deferral will be not operated for this case. |
| CATT | Maybe we can check the question based on the inputs from Qualcomm first. |
| FGI/APT | We support Alt. 1 |
| LG | Support Alt. 1 |
| Huawei | Alt.1. The question itself needs to be clarified in advance though. |
| Lenovo, Motorola Mobility | Alt 1 can make a payload size of deferred and non-deferred HARQ-ACK reasonable. |
| Ericsson | Alt 1.  When the codebook contains dynamic HARQ-ACK, it can be expected that dynamic PUCCH resource should be valid and thus the codebook can be transmitted. |

Qualcomm [16] moreover discusses that SPS HARQ-ACK of more than one PUCCH slot could be subject to deferral and are then together deferred to a target slot. Just to be sure companies are having the same understanding, the following question is brought forward. **Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below.**

**Question 2.7: For SPS HARQ-ACK deferral,**

* **Alt. 1: only the SPS HARQ bits subject to deferral from the ‘last’ initial PUCCH slot are subject to deferral (SPS HARQ bits from ‘earlier’ initial PUCCH slots are dropped)**
  + **Supporting companies: Nokia/NSB, ZTE, Samsung,** …
* **Alt. 2: SPS HARQ bits from more than one ‘initial PUCCH slot’ can be jointly deferred** 
  + **Supporting companies: OPPO, Panasonic, Sony, Intel, Sharp, DOCOMO, Qualcomm, ETRI, NEC, CATT, China Telecom, FGI/APT, LG, Huawei, Lenovo/Motorola Mobility** …
* **Alt. 3: Other**
  + **Supporting companies:** …

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| *Company* | *Comments or Alt. 3 – other options* |
| Nokia/NSB | Alt. 1 for simplicity. As for earlier issues, we don’t see a need to over-optimize the operation. |
| OPPO | Alt.2 simplicity.  All SPS HARQ bits satisfying defer limit should be considered. It is not necessary to add new restriction, e.g. “last” or “earlier” initial PUCCH, which increases implementation and specification complexity. |
| vivo | See our comments for Question 2.6. In case that the entire HARQ-ACK codebook only includes the HARQ-ACK for SPS PDSCH, if the codebook is dropped due to collision with semi-static DL symbols/SSB, we think the entire HARQ-ACK codebook should defer further, i.e., Alt.2.  Moderator comment: see my reply in Q2.6 |
| Panasonic | Alt. 2, transmitting SPS HARQ bits from several PUCCH resources can provide a better performance. Configuring the deferral period (*k1def*) for SPS configurations enables adjusting the load of deferred HARQ-ACKs. |
| Sony | Alt .2. Since we define a *k1def*, we do not see why this *k1def* should be limited to only 1 PUCCH. |
| Intel | Alt. 2 |
| Sharp | Alt .2. We share the similar views with Panasonic and Sony. |
| ZTE | Alt. 1. The case of more than one PUCCH slot could be subject to deferral is very rare. Alt. 1 is simple. |
| DOCOMO | We first want to confirm our understanding on Alt 1 and Alt 2.  For the following example case:    With Alt 1, HARQ-ACK for SPS PDSCH#1 and 2 are dropped. HARQ-ACK for SPS PDSCH#3 is deferred on slot #n+3.  With Alt 2, HARQ-ACK for SPS PDSCH #1, #2 and #3 are deferred on slot #n+3.  In our understanding, SPS HARQ-ACK deferral is stopped when target slot is determined or maximum K1 limitation is violated. Once target slot is determined, the SPS HARQ-ACK bits can’t be further deferred. For the example case, in slot #n+2, PUCCH resource determined for the “deferred two bits and one new bit” overlaps with DL symbol. Therefore, slot #n+2 is not the target slot for the “deferred two bits for SPS PDSCH#1/2”. The three HARQ-ACK bits for SPS PDSCH #1/2/3 will be further deferred to next slot. |
| Samsung | Alt.1 - We don’t think that this is general case for optimization. |
| Qualcomm | Alt 2. It is clarified here, that QC’s proposal was for more than 1 SPS HARQ CBs from the same SPS configuration colliding with DL symbols on different slots. The case can be extended for more than 1 SPS configurations. Since maximum deferral time is defined, Alt 1 is against this agreement.  To DoCoMo: we share the same understanding with your example and the description. |
| NEC | Alt.2.  For Alt.2, if the deferred SPS HARQ-ACK bits from more than one initial PUCCH slot are for different SPS PDSCHs, when their target slot is a same slot, and the k1+k1def of each deferred SPS HARQ-ACK bit satisfies the condition, multiplexing these SPS HARQ-ACK bits on a deferred PUCCH resource is reasonable. |
| FGI/APT | We support Alt. 2. Restriction imposed by Alt. 1 is not necessary. |
| LG | Alt. 2. |
| Huawei | Alt.2. Align with DoCoMo’s understanding. As per the simple and unified SPS deferral procedure we mentioned in the reply to Question 2.5, the deferred HARQ-ACK should be allowed to further defer to the next candidate slot if the current slot cannot provide enough UL resources for transmitting the UCI. Unnecessarily dropping the deferred HARQ-ACK will weaken the value of the SPS HARQ-ACK deferral feature. |
| Lenovo, Motorola Mobility | Alt 2. UE should be able to defer HARQ-ACK bits from more than one ‘initial PUCCH slot’, as long as the delay values are within the configured max delay. |
| Ericsson | If it is clarified that the deferral condition also takes into account possible multiplexing in a slot, then the whole HARQ-ACK CB is subject to deferral. There should not be a split of HARQ-ACK bits in a codebook where some are deferred, some not.  Our understanding is similar to DCM and HW.  Is that align with Alt 2? |

Also, on the HARQ-ACK codebook construction in the target slot, there had been rather divergent input as there are separate cases to be considered, namely SPS HARQ-only, Type 1 CB and Type 2 CB to be configured. **Some companies prefer common handling for all cases for simplicity, and some companies prefer some case specific optimizations (specifically for Type 1 CB, for all other cases the different options proposed result in the same HARQ-ACK codebook size but may just lead to different bit ordering).**

**Question 2.8: For SPS HARQ-ACK deferral, the multiplex of deferred HARQ-ACK and initial HARQ-ACK bits in the target sloe is**

* **Alt. 1: common for all cases / combinations of deferred SPS HARQ and initial HARQ-ACK bits by simply appending the deferred SPS HARQ-ACK bits to the initial HARQ bits / codebook**
  + **Supporting companies: Nokia/NSB, OPPO, Panasonic, Sony, Intel, Sharp, DOCOMO, TCL, Qualcomm, ETRI, NEC, CATT, China Telecom, LG, Lenovo/Motorola Mobility, Ericsson**
* **Alt. 2: the multiplexing is case specific, i.e. different procedures are applied to SPS HARQ-only, Type 1 HARQ codebook and Type 2 HARQ codebook**
  + **Supporting companies: vivo, ZTE, FGI/APT, Huawei** …
* **Alt. 3: Other**
  + **Supporting companies:** …

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| *Company* | *Comments or Alt. 3 – other options* |
| Nokia/NSB | Alt. 1 for simplicity. The only difference is for Type 1 HARQ-ACK codebook size but as the number of deferred SPS HARQ-ACK bits should not be that many compared to the Type 1 CB size, we see this as an unnecessary optimization (and specification complication). |
| OPPO | Alt. 1 for simplicity. |
| vivo | One typo in the question, “sloe” should be “slot”.  Alt.2. All types e.g., Type 1 CB, Type 2 CB and SPS only case can almost reuse current construction procedure. The complexity, in terms of needed specification efforts, is comparable with Alt.1. |
| Panasonic | Alt. 1 is a unified and simple solution. It just needs to sort deferred HARQ-ACKs and amend them to the existing codebook. |
| Sony | Alt. 1. Unclear what we gain by having different multiplexing schemes for different scenario. |
| Intel | Alt.1, we don’t see clear motivation for different handling |
| Sharp | Alt. 1 for simplicity. |
| ZTE | Alt. 2. We think the multiplex of deferred HARQ-ACK and initial HARQ-ACK bits in the target slot for type-1 codebook generation could be considered to optimize the codebook size. We propose:  *If the slot with SPS PDSCH is contained in the semi-static HARQ-ACK codebook window corresponding to the semi-static HARQ-ACK codebook for the DG PDSCHs, then UE constructs a HARQ-ACK codebook containing the deferred HARQ-ACK and HARQ-ACKs of the DG PDSCHs according to the semi-static HARQ-ACK codebook mechanism, but the actual HARQ-ACK is always generated for the slot with SPS PDSCH, just like the SPS PDSCH is treated as DG PDSCH.* |
| DOCOMO | Alt 1.  Alt 1 is simple and we don’t see obvious benefit of other more complicated solutions over Alt 1. |
| Samsung | Alt. 1.  Alt. 2 requires additional specifications for defining additional k1 set due to deferring in case of type 1 HARQ-ACK codebook. |
| TCL | We support Alt.1. Since this has less specification impact. |
| Qualcomm | Alt 1. The reasons are mentioned above. |
| NEC | Alt.1. Alt.1 is simple. |
| CATT | Although we see some benefit of Alt. 2 in terms of overhead reduction, Alt. 1 seems to be reasonable way forward at this stage. |
| China Telecom | Alt. 1 for simplicity. |
| FGI/APT | Alt. 2. Deferred SPS HARQ-ACK bits should be ordered based on the corresponding PDSCH when multiplexed in a Type-1 HARQ-ACK codebook. Alt. 1 may break the nature of semi-static codebook size of Type-1 HARQ-ACK codebook when DCI miss detection happens. |
| LG | Alt.1 could be a baseline. |
| Huawei | Alt.2. For the multiplexing of DG HARQ-ACK and SPS HARQ-ACK, the procedures for CB construction are already separated for the legacy system (9.1.2 for Type 1 and 9.1.3 for Type 2 in 38.213). In our understanding, the deferred HARQ-ACK should be appended to the end of the DG type 2 CB as the same in R15 rule. However, simply appending all of the deferred HARQ-ACK to the DG type 1 CB would cause redundancy. As shown in the following figure, assuming the SPS PDSCHs in slot#1~#3 are deferred to slot#5, SPS PDSCH in slot#4 initially points to slot#5, and there comes another DG DCI pointing the DG HARQ-ACK with type 1 CB to slot#5, where the K1 set = {1,2,3}. If simply appending all the deferred/initial SPS HARQ-ACK to the end of the DG type 1 CB, the total CB should be: DG type 1 CB {1, 2, 3} and SPS HARQ-ACK CB {1, 2, 3, 4}, which are totally 7 bits. However, it is observed that there are 3 redundant bits {1,2,3}. Therefore, we think these redundant bits should be removed from the SPS HARQ-ACK CB for saving the payload. Thus the SPS CB should be the HARQ-ACK not included in the Type 1 K1 set, i.e. {4}, and the total payload is therefore optimized to 4 bits. |
| Lenovo, Motorola Mobility | Alt 1 |
| Ericsson | Alt 1.  Aim for simplicity. |

* 1. 1st checkpoint proposals (Aug. 19th)

Looking at the input received on question 2.1 (see above), there is a strong majority of companies proposing to define the max. deferral by RRC configuration per SPS configuration. Therefore, the following is proposed to be agreed (supporting companies from first round already included):

**Modified Proposal CP2.1: For SPS HARQ-ACK deferral, the maximum deferral value in terms of k1+k1def is ~~determined~~~~by~~ RRC configured~~ation~~ per SPS configuration.**

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| Supporting companies | Nokia/NSB, Panasonic, Sony, Intel, Sharp, DOCOMO, Samsung, Spreadtrum, ETRI, Qualcomm, NEC, CATT (2nd preference), China Telecom, FGI/APT, Lenovo/Motorola Mobility, OPPO, vivo, Huawei |
| Objecting companies |  |

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| *Company* | *Comments* |
| vivo | We can accept the proposal for sake of progress. |
| China Telecom | Is enabling/disabling of SPS HARQ-ACK deferral per SPS configuration independent RRC signaling, or can be implicitly determined by the maximum deferral value configuration, i.e. determined based on whether the configured maximum deferral k1+k1defequals to k1 of the same SPS?  Moderator comment: the idea is to RRC configure the value (based on the first round input given). Better to clarify this to leave no ambiguity. Proposal updated accordingly |
| Huawei | We can live with it from progress. |
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Looking at the input received on question 2.2 (see above), there is a strong majority of companies proposing either to confirm the working assumption on HARQ process handling as it is (Alt. 1) whereas an about equal number of companies supporting Alt. 3 with minor updates, which is pointed out by some companies to be actually more accurate than the original WA of Alt. 1. Alt. 2 and Alt. 4 received only minor support. Considering the input given, it is suggested to confirm the WA with the updates according to Alt. 3 (as this seems to be more accurate (supporting companies from first round of Alt. 3 already included):

**Proposal CP2.2: For SPS HARQ-ACK deferral, confirm the RAN1#104b-e working assumption with the following updates:**

**Working assumption: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:**

* **In case the UE is expected to receive~~s~~ PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.**

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| Supporting companies | Nokia/NSB, OPPO, vivo (1st preference), Panasonic, Intel, Sharp, ZTE, Spreadtrum, TCL (1st) , Qualcomm (1st) , NEC, ETRI, China Telecom, FGI/APT, LG, Huawei, Lenovo/Motorola Mobility, Ericsson, Mediatek |
| Objecting companies | CATT (would like to clarify companies’ understanding on our earlier comment before confirming the WA) |

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| *Company* | *Comments* |
| CATT | We had the following comments in the 1st round discussion.  *One general comment is that we see potential problem of misalignment between gNB and UE on the number of bits of deferred HARQ-ACK in case DCI is missed. For example, in case an SPS PDSCH occasion with same HARQ process ID as deferred SPS HARQ bit(s) is overridden by a DCI scheduling a dynamic PDSCH with a different HARQ process ID, if the scheduling DCI is missed at the UE side, UE would drop the deferred SPS HARQ bit(s) for the HARQ process ID while gNB has a different understanding. Another example is that if UE is scheduled to receive a PDSCH with the same HARQ process ID as the deferred SPS HARQ bit(s) and the scheduling DCI is missed, UE does not drop the deferred SPS HARQ bit(s) for the HARQ process ID while gNB has a different understanding. We would like to hear companies’ views on that.*  Moderator comment: Isn’t the missed DCI issue (which we discussed extensively) present for the DG PDSCH overriding also if a different HARQ-ID is scheduled? So the issue that CATT is raising is not just specific to HARQ ID collision, but a general issue.  At least from moderator perspective, therefore there seems to be no need to handle this specifically in case the same HARQ process / ID is scheduled. |
| Intel | We think CATT examples are valid, but those can be addressed later |
| Sony | I think the issue from CATT is for cases where the SPS with the deferred HARQ-ACK requires retransmission. If that SPS does not require retransmission then it is ok to be overwritten otherwise, the any misalignment will mess up the HARQ combining at the UE.  Moderator: Please note that this issue is there since Rel-15, that HARQ buffer is flushed if a new PDSCH with same HARQ-ID is received. So nothing new |
| Huawei | Just a clarification question: in the bullet ‘UE is expected to receive PDSCH’ implies the PDSCH is SPS PDSCH, right? Otherwise the UE cannot ‘expect to receive’ a dynamic PDSCH. Hope this may somewhat relieve CATT’s confusion. For the 1st case, the gNB can blind detect the two hypothesis, while for the 2nd case, the gNB can avoid scheduling the DG with the same HARQ ID.  Moderator: the expected includes DG PDSCH to my reading, as based on a DCI scheduled PDSCH the UE is expected to receive. The change was only done, based on Intel pointing out that a skipped SPS PDSCH cannot be received. I hope this clariies. |
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Looking at the input received on question 2.3, there is a strong majority of companies proposing to adopt the same handling as in the initial slot (i.e. Alt. 1) and moreover, take the HARQ-ACK multiplexing into account. Some minor wording change is done compared to Alt. 1A is suggested, as the intention was not to discussion target cell but it was all about target PUCCH slot determination (thanks OPPO for the comment to point this somehow out). Therefore, the following is proposed (indications for Alt. 1A during RAN1 already included in the table):

**Modified Proposal CP2.3: For SPS HARQ-ACK deferral, the ~~next available PUCCH (i.e.~~ target PUCCH slot~~)~~ is defined as the next PUCCH slot where ~~earlier of~~ *sps-PUCCH-AN-List-r16* or  *n1PUCCH-AN* is regarded as valid*,* or a ~~dynamically indicated~~ PUCCH resource *(from PUCCH-ResourceSet*) is dynamically indicated**

* **The target PUCCH slot determination ~~cell definition~~ takes the HARQ-ACK multiplexing in the target PUCCH slot into account**
* **The final PUCCH resource selection in the target PUCCH slot in terms of PUCCH resource set and PUCCH resource ID follows the Rel-16 procedures.**
* *Moderator comment / understanding: This seems aligned with the handling in the initial slot*

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| Supporting companies | Nokia/NSB, vivo, Panasonic, Intel, Sharp, ZTE, DOCOMO, Samsung, ETRI, CATT, China Telecom, FGI/APT, Huawei, Lenovo/Motorola Mobility, NEC, QC, Spreadtrum, OPPO, Sony |
| Objecting companies | LG (further clarification is needed) , CATT (with clarification) |

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| *Company* | *Comments* |
| QC | This proposal is ok for the case in which SPS HARQ-only collides with DL symbols AND the “target slot” does not contain new CSI.  For the sake of providing a complete solution, useful to start discussion for the cases   * Initial SPS HARQ + CSI collide with DL * “Target slot” contain new CSI * In case the “target slot” contains new CSI & “the target PUCCH slot determination takes the HARQ-ACK multiplexing in the target PUCCH slot into account”, then, the UE, needs to search for appropriate PUCCH resource in the *multi-CSI-PUCCH-ResourceList* or *pucch-CSI-ResourceList* and NOT in the *sps-PUCCH-AN-List-r16.* |
| LG | We are fine with the proposal in principle. However, it is still unclear how UE consider UL multiplexing in the target slot and how to determine PUCCH resource in the target slot. Following has to be further clarified.   * For the target PUCCH slot determination, is deferred HARQ-ACK bit considered?   + In other words, only non-deferred HARQ-ACK bits are considered or both non-deferred and deferred HARQ-ACK bit are considered for the target PUCCH slot determination? * For the final PUCCH resource selection, is deferred HARQ-ACK bit considered?   + In other words, only non-deferred HARQ-ACK bits are considered or both non-deferred and deferred HARQ-ACK bit are considered for the final PUCCH resource selection? * If different payload size is considered between for the target slot determination and final PUCCH selection, does UE checks availability/validity of PUCCH resource only for target slot determination?   + This is connected to CP 2.4.   Moderator: hope that it should be clear that the total payload size is considered and the PUCCH resource selection based on the two sub-bullets   * ***The target PUCCH slot determination ~~cell definition~~ takes the HARQ-ACK multiplexing in the target PUCCH slot into account*** * ***The final PUCCH resource selection in the target PUCCH slot in terms of PUCCH resource set and PUCCH resource ID follows the Rel-16 procedures.*** |
| CATT | We supported the proposal in the 1st round since we think it is the same rule as for initial slot as commented by moderator. However, when we review the proposal, it seems not clear whether we are talking about PUCCH resource or PUCCH slot (next available PUCCH (i.e. target PUCCH slot)). In addition, it is not clear what “earlier” means here. It can be understood as the PUCCH resource which starts earliest within the target slot. Therefore, we think the wording of the proposal may need to be changed.  Moderator: good point on the PUCCH resource. The intention clearly is to use the earlier slot, where one of these resources is available. Try to update this. |
| ZTE | Fine with the proposal. Just one question to be clarified, the final PUCCH resource selection in terms of PUCCH resource set means the target PUCCH slot determination should consider the conditions such as payload size accommodation, PUCCH format matching, when the multiplexing is taken into account. |
| Ericsson | We think the proposal should be clarified that the part of dynamic indicated PUCCH resource, **dynamically indicated PUCCH resource *(from PUCCH-ResourceSet*)**, is only applicable when there is multiplexing with HARQ bits corresponding to dynamic PDSCH in the same slot/sub-slot. Otherwise, if there are only SPS HARQ-ACK bits including the deferred ones, then only ***sps-PUCCH-AN-List-r16* or *n1PUCCH-AN*** should be considered for the next available PUCCH for SPS HARQ-ACK. With this clarification, then we can understand that it is aligned with the agreed handling in the initial slot. |

Also for the feedback on Question 2.4, there seems to a very good support for Alt. 1. Some questions had been there, please check the moderator answers in the table there. Therefore, Alt. 1 is proposed to be adopted (supporting companies from Round 1 included already):

**Proposal CP2.4: For SPS HARQ-ACK deferral, if after the ~~determination of a~~ target PUCCH slot determination the deferred SPS HARQ-ACK cannot be transmitted (e.g. due to SFI indication or due to slot format change resulting in new collision with DL~~similar~~), the deferred SPS HARQ-ACK bits are not further deferred and are dropped.**

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| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Intel, Sharp, DOCOMO, CATT, China telecom, NEC, Huawei, Ericsson, LG, Spreadtrum, Mediatek |
| Objecting companies | Sony |

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| --- | --- |
| *Company* | *Comments* |
| QC | Is the motivation here to capture the network’s intention to turn the PUCCH resource in the target slot to something not valid? E.g   * SPS HARQ deferred to a target slot on a given PUCCH resource and this PUCCH resource is not available in the target slot due to   - SFI indicating that the dynamic flexible symbol turns into DL symbol or  - a new slot configuration change turns the flexible or UL symbols in DL symbols?  Or, what else was intended with the term “similar”?  If yes, suggested wording  **For SPS HARQ-ACK deferral, if after the target PUCCH slot determination the deferred SPS HARQ-ACK cannot be transmitted (e.g. due to SFI indication or due to slot format change resulting in new collision with DL~~similar~~), the deferred SPS HARQ-ACK bits are not further deferred and are dropped.**  Moderator: modified above. |
| LG | Fine with Qualcomm’s modification as well. |
| Sony | It is strange that a target PUCCH is still called a target PUCCH if it is dropped. Proposal CP2.3 just said that the target PUCCH slot would have sps-PUCCH-AN-List-r16 or n1PUCCH-AN is regarded as valid and that there is a PUCCH indicated by a dynamic grant. This is contradicting the previous proposal. Also isn’t a dynamic grant used as the last determining step in determine whether a FL symbol is DL or UL? So if there is a dynamic grant PUCCH, how is it possible that the SFI had changed it?  Perhaps there is an issue in the terms used in this proposal. Proposal CP2.3 needs to go together with Proposal CP2.4.  Moderator: please note, that the PUCCH may be valid but the UCI is mapped to overlapping PUSCH which is then canceled by Rel-16 UL CI. So overall we will never be able to prevent dropping, there will be always cases that this happens. But the point here is, if based on the rule for the target PUCCH slot it has been determined, you try to transmit the def. SPS HARQ but it may fail to be transmitted. |
| Huawei | It is not clear what other cases would be included to ‘**the deferred SPS HARQ-ACK cannot be transmitted**’. E.g., if the target slot is originally (semi-statically) configured as all ‘DL’, this case looks also belong to a generic situation of ‘**the deferred SPS HARQ-ACK cannot be transmitted**’, but obviously the deferred SPS HARQ-ACKs should be further deferred as in Proposal CP 2.6.  Therefore we suggest the proposal is limited to the SFI changing case and is modified as follows:  **For SPS HARQ-ACK deferral, if after the ~~determination of a~~ target PUCCH slot determination the deferred SPS HARQ-ACK cannot be transmitted ~~(e.g.~~ due to SFI indication or due to slot format change resulting in new collision with DL~~similar)~~, the deferred SPS HARQ-ACK bits are not further deferred and are dropped**  Moderator: please note, that the PUCCH may be valid but the UCI is mapped to overlapping PUSCH which is then e.g. cancelled by Rel-16 UL CI. Therefore, this may not be the only case that deferred SPS HARQ-ACK can be transmitted.  So we either keep this in brackets as is, or remove the bracket overall. |
|  |  |

Based on question 2.6, there had been a strong majority of companies indicating their support for Alt. 1. Therefore, this is proposed to be agreed (supporting companies of included in the table below already):

**Modified Proposal CP2.5: For SPS HARQ-ACK deferral, only SPS HARQ bits subject to deferral from HARQ-ACK codebook from an ~~in the~~ initial PUCCH slot are deferred to the target PUCCH slot**

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| Supporting companies | Nokia/NSB, Panasonic, Sony, Intel, Sharp, ZTE, DOCOMO, Samsung, TCL, NEC, ETRI, FGI/APT, LG, Huawei, Lenovo/Motorola Mobility, Ericsson, OPPO, vivo (with modification), China telecom, Mediatek |
| Objecting companies | CATT (no objection, but would like to clarify the proposal) |

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| *Company* | *Comments* |
| QC | In general, the case addressed with this proposal can be avoided by the gNB scheduling. The network should avoid scheduling DG PDSCH HARQ on a sub-slot which is going to turn into DL sub-slot. The network can also avoid grouping SPS HARQ bits from two different SPS configurations with different configurations in terms of SPS HARQ deferral.  Not of highest priority. |
| CATT | The proposal itself is not so clear to us. From the clarification from moderator, our understanding of the proposal is to exclude case 2 and 4 below.   * Q 2.6: This is the handling for a single HARQ-ACK codebook. Let’s for simplicity consider we have a PUCCH slot containing a HARQ-CB which is dropped based on the agreed Alt. 1 (i.e. no PHY prioritization, only collision with the defined ‘invalid’ symbols). The HARQ-ACK codebook may contain:   1. ‘new/initial’ SPS HARQ configured for deferral   2. ‘new/initial’ SPS HARQ not configured for deferral   3. Deferred HARQ-ACK   4. DG PDSCH HARQ   We share the same understanding as Qualcomm that case 4 is an error case. For case 2, shouldn’t it be clear from our agreements on Monday?  **Agreement**  The SPS HARQ-ACK deferral is enabled per SPS configuration   * Note: part of sps-config, only HARQ-ACK of SPS PDSCH configurations enabled for deferral is in principle subject to deferral   Moderator: I think it should be clear, but as there had been proposals going into this meeting that the overall codebook (containing 1..4) should be transferred, maybe good to agree (to prevent any misunderstanding) |
| vivo | Thanks a lot moderator’s explanation in the 1st round. Now we have better understanding that the intention of this proposal is to support defer the 1) ‘new/initial’ SPS HARQ configured for deferral and the 2) ‘old/previous’ deferred HARQ-ACK and do NOT defer the 3) ‘‘new/initial’ SPS HARQ not configured for deferral’ if 1), 2) 3) are in the same codebook but dropped due to collisions.  We are supportive for the Proposal CP2.5 in principle, but we would like to remove “in the initial PUCCH slot” or modify it as “in the initial PUCCH slot(s)” since the initial PUCCH slot for above 1) and 2) is different.  Moderator: I fail to understand here, but tried to address that this is not a specific initial slot.  Moderator 2: Now I get it, sorry. Please note, that I still think the current formulation is fine (without removal / adding plural ‘s’), as (i) for the deferred SPS HARQ-ACK in that slot it is the target slot (if it had been determined to be the target slot, otherwise they would not be part of the codebook) and (ii) based on Proposal CP2.4, we discuss to prevent further deferral if dropping is needed. So, I guess there should not be any issues?? |
| Intel | Fine if similar understanding with CATT/vivo is confirmed |
| Huawei | Reading the comments of CATT/vivo, we hope a note can be added to make the motivation/background of this proposal clearer. Modifications as follows.  **For SPS HARQ-ACK deferral, only SPS HARQ bits subject to deferral from HARQ-ACK codebook from a ~~in the~~ initial PUCCH slot are deferred to the target PUCCH slot**   * **Note: SPS HARQ bits not subject to deferral from HARQ-ACK codebook in the initial PUCCH slot are not deferred**   Moderator: I guess this could be added, but would we then need to add also DG PDSCH and already deferred SPS HARQ bits based on Proposal CP 2.4. I guess the ‘only’ should be sufficient? |

On Question 2.7, there seemed to be a strong majority of companies suggesting to not apply any further restrictions on number of initial PUCCH slots that can be jointly deferred to a target slot (i.e. Alt. 2). Therefore, the following is proposed to be agreed (supporting companies of Round 1 already included):

**Proposal CP2.6: For SPS HARQ-ACK deferral, deferred SPS HARQ bits from more than one ‘initial PUCCH slot’ can be jointly deferred to a target PUCCH slot**

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| Supporting companies | OPPO, Panasonic, Sony, Intel, Sharp, DOCOMO, Qualcomm, ETRI, NEC, CATT, China Telecom, FGI/APT, LG, Huawei, Lenovo/Motorola Mobility, vivo, Mediatek |
| Objecting companies |  |

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| *Company* | *Comments* |
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Also on question 2.8, there is a strong majority for supporting the simple solution for handling the multiplexing of deferred SPS HARQ information and ‘new, initial’ HARQ-ACK information in the target slot. Therefore, it is suggested to agree on this (supporting companies from 1st round included below already):

**Proposal CP2.7: For SPS HARQ-ACK deferral, in the target PUCCH slot the deferred SPS HARQ-ACK bits are appended to the initial HARQ bits / Type 1 or Type 2 codebook.**

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| Supporting companies | Nokia/NSB, OPPO, Panasonic, Sony, Intel, Sharp, DOCOMO, TCL, Qualcomm, ETRI, NEC, CATT, China Telecom, LG, Lenovo/Motorola Mobility, Ericsson, Samsung, Mediatek |
| Objecting companies | Vivo, Huawei |

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| *Company* | *Comments* |
| vivo | We failed to see how Alt.2 is more complex than Alt.1.  For Alt.2 that the multiplexing is case specific, all the three cases: Type 1 CB, Type 2 CB and SPS only case reuses current construction procedure. For Alt.1, if we treat all the three cases the same way, more spec efforts compared to Alt.1 is required. In addition, Alt.1 will result in more overhand compared to Alt.1.  Moderator: The complexity comes from the Type 1 HARQ-ACK HARQ-ACK constructions – as with this, the UE can use the same pseudo-code for the target slot without considering the deferred bits, the other alternative the UE needs to change the Type 1 CB construction to take into account deferred bits actually not having had the k1 associated (using k1+k1\_def). Of course, complexity is always a matter of opinion.  Of course different companies have different preferences here, but I guess this is a Alt. 1 or Alt. 2 decision. Do you think vivo will be able to convince the 15+ companies the other way? Some flexibility would be appreciated. |
| ZTE | We don’t strongly object the proposal. But share the same view with vivo that simply appending bits may not be the simple way.  Also the optimization of codebook construction is deserved. With the example from Huawei in 1st round discussion, overhead is 7 bits before optimization and 3 bits after optimization. |
| Huawei | As we commented in the first round, for Type 1 CB, the redundancy bits can be removed from the SPS HARQ bits to save the total payload.    Therefore we recommend the proposal to be modified as below:  **For SPS HARQ-ACK deferral, in the target PUCCH slot the deferred SPS HARQ-ACK bits are appended to the initial HARQ bits / Type 1 or Type 2 codebook.**   * **FFS the redundant HARQ-ACK bits between Type 1 codebook and deferred SPS HARQ-ACK bits for which the k1+ k1def is included in the K1 set of the Type 1 codebook**   Moderator: I guess the proposal by Huawei and other companies to optimize for Type 1 CB is understood by the group. Please adding such note would be against the main bullet. So if we agree this with the FFS, then we have a contradiction in the proposal that the FFS is already clarified by the main bullet / sentence. |
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* 1. 2nd and 3rd Round of email discussions

**Proposals not agreeable transferred from the 1st checkpoint:**

On proposal CP 2.2., CATT proposed an addition of an FFS point to CP2.2, based on the following comment:

* *My understanding of the proposal is that if a deferred SPS HARQ bit(s) is dropped, the AN bit location for this deferred SPS PDSCH is excluded in the subsequent HARQ-ACK transmission meaning that the HARQ-ACK codebook size is changed. With this understanding, the issue is different from Rel-15 since in Rel-15 the HARQ-ACK CB size is not impacted. We are fine with Intel’s proposal to address this issue later. But we would like to confirm the understanding first. If the understanding is correct, we would like to add an FFS for the issue, e.g. FFS the subsequent HARQ-ACK transmission of the dropped SPS HARQ bit(s).*

Maybe let’s have a discussion on this point to see if we need to add some FFS to Proposal CP2.2, as suggested by CATT. At least it is moderator’s understanding, the transferred SPS HARQ-ACK bits are not actually to be regarded as a ‘CB’, but just the set of SPS HARQ-ACK bits to be deferred (i.e. in the target PUCCH slot determination). So not really sure what the problem is there. Please note, the same applies if different maximum deferral values are configured for the UE. Also in this case, there could be a change in payload size of the deferred SPS HARQ-ACK over time.

**Question 2.4.1: Do you think some specific handling or clarification would be needed for the working assumption on collision of the same HARQ process due to deferred SPS HARQ? If so, how would this be handled (see moderator discussion above)?**

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| Yes | Sony, CATT, Panasonic |
| No | Huawei, Nokia/NSB, Lenovo/Motorola Mobility, vivo，OPPO, Spreadtrum, ZTE, NEC |

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| --- | --- |
| *Company* | *Comments* |
| Sony | Firstly, I think dropping deferred SPS HARQ bits is a sledge hammer approach. Some of these SPS may require retransmission.  Secondly on CATT’s point, we think the deferred HARQ-ACK for the dropped SPS should be transmitted in the targeted PUCCH. That it, it should NOT be removed form the CB. Dropping the SPS HARQ bits is bad enough especially when it requires retransmission. If we start to drop the corresponding HARQ-ACK, it will make it worse especially if the HARQ-ACK is an ACK since it lead to unnecessary retransmission (which is this HARQ-ACK deferral feature tries to avoid). Hence, rather than add a FFS we should just say that the deferred HARQ-ACK for the dropped SPS is transmitted, i.e.:  **To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:**   * **In case the UE is expected to receive~~s~~ PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.** * **The HARQ-ACKs for the dropped deferred SPS HARQ bits are transmitted in the target PUCCH**   Moderator: Please check the responses from 1st round and the discussions from RAN1#104bis-e. This would require the UE to store HARQ-ACK information which is not valid any longer (as the HARQ buffer had been flushed). |
| Huawei | Even as Moderator clarified, the expected PDSCH includes DG PDSCH, we think it can be avoided based on gNB implementation/judging. E.g., if the gNB has to warrant the reliability and avoid the misunderstanding of SPS CB size, it should avoid scheduling with the same HARQ ID with the deferred SPS. |
| QC | The cases mentioned by CATT are not a problem. For the sake of easiness, below CATT’s comments (in blue) (“*in case an SPS PDSCH occasion with same HARQ process ID as deferred SPS HARQ bit(s) is overridden by a DCI scheduling a dynamic PDSCH with a different HARQ process ID, if the scheduling DCI is missed at the UE side, UE would drop the deferred SPS HARQ bit(s) for the HARQ process ID while gNB has a different understanding.”*).  The 1st “misalignment” example mentioned is the one in which   1. SPS HARQ collides at slot *#t*, SPS HARQ is deferred to next available PUCCH resource, SPS HARQ uses the HARQ Process ID #L 2. UE find the first available PUCCH resource at slot #(t + N) 3. A new SPS PDSCH is scheduled for transmission at slot #S, and SPS HARQ for this new UCI payload is #(t + N). Hence, the total payload in the slot #(t + N) is equal to the sum of i) new SPS HARQ bits and ii) deferred SPS HARQ bits. 4. The new SPS HARQ is using the same HARQ Process ID (#L) as the initial SPS HARQ which is deferred. 5. The network allocates DG PDSCH whose PUCCH is scheduled on slot #(t + N) and the HARQ process ID (#M) for this DG PDSCH HARQ is different from the HARQ Process ID (#L) used for new and deferred SPS HARQ. 6. UE misses DCI for DG PDSCH and associated HARQ 7. UE drops SPS HARQ bits since UE expects new HARQ bits on the same HARQ Process ID.   First of all, the case of step 4 above – same HARQ Process ID for new and deferred SPS HARQ bits is not realistic. For the following 2 reasons:  **Reason 1: Maximum deferral time is set so as UE stops deferring when new SPS packet arrives**.  **Reason 2: HARQ Process ID is for a given SPS PUCCH is dynamically selected upon each SPS PUCCH occasion. This dynamic selection is based on current slot index (see 38.321).**  However, for the sake of discussion, imagine that the whole sequence above is executed. The UE drops the deferred SPS HARQ packet, which is not a problem since the DL packet for which HARQ bits are addressed, has already expired. In common IIOT traffic scenarios, the arrival of new packet makes the previous packet obsolete.  The 2nd case mentioned by CATT is not a very realistic scenario either. The UE has usually 8 different HARQ Process IDs for SPS and 16 HARQ process IDs for DG PDSCH HARQ, why would the network schedule a new DG PDSCH HARQ on a HARQ ID that the network knows that is occupied by deferred SPS HARQ bits? There are 15 other different HARQ Process IDs the network can choose from. In addition, if all of the other 15 HARQ Process IDs are full, then, the maximum deferral time can take care of this eventual collision.  However, even if the 2nd case mentioned by CATT (*Another example is that if UE is scheduled to receive a PDSCH with the same HARQ process ID as the deferred SPS HARQ bit(s) and the scheduling DCI is missed, UE does not drop the deferred SPS HARQ bit(s) for the HARQ process ID while gNB has a different understanding*), is not a problem. The network detects immediately that the UE missed the DCI and the network keeps on expecting the deferred SPS HARQ bits on the “1st available PUCCH resource”  Below the steps   1. SPS HARQ collides at slot *#t*, SPS HARQ is deferred to next available PUCCH resource, SPS HARQ uses the HARQ Process ID #L 2. UE find the first available PUCCH resource at slot #(t + N) 3. A new DG PDSCH is scheduled for transmission at slot #S, and DG PDSCH HARQ for this new UCI payload is #(t + N). Hence, the total payload in the slot #(t + N) is equal to the sum of i) new DG PDSCH HARQ bits and ii) deferred SPS HARQ bits.   Network allocation of the same HARQ Process ID #L for this DG PDSCH HARQ and for deferred SPS HARQ.   1. UE misses DCI for DG PDSCH and associated HARQ 2. UE does not drop deferred SPS HARQ bits from HARQ Process ID #L. 3. gNB detects the absence of DP PDSCH HARQ and deferred SPS HARQ bits on the allocated PUCCH resource. 4. gNB realizes that the UE still has the deferred SPS HARQ bits (if not expired) and gNB continues monitoring reception of deferred SPS HARQ bits on 1st available PUCCH resource.   *“One general comment is that we see potential problem of misalignment between gNB and UE on the number of bits of deferred HARQ-ACK in case DCI is missed. For example, in case an SPS PDSCH occasion with same HARQ process ID as deferred SPS HARQ bit(s) is overridden by a DCI scheduling a dynamic PDSCH with a different HARQ process ID, if the scheduling DCI is missed at the UE side, UE would drop the deferred SPS HARQ bit(s) for the HARQ process ID while gNB has a different understanding. Another example is that if UE is scheduled to receive a PDSCH with the same HARQ process ID as the deferred SPS HARQ bit(s) and the scheduling DCI is missed, UE does not drop the deferred SPS HARQ bit(s) for the HARQ process ID while gNB has a different understanding. We would like to hear companies’ views on that.”* |
| Lenovo/Motorola Mobility | The issue of missing DCI that indicates the same HARQ process ID can be easily avoided by gNB implementation.  When UE misses DCI that overrides a SPS PDSCH occasions of the same HARQ process ID with a DG PDSCH of a different HARQ process ID, the UE drops SPS HARQ bits and corresponding deferred SPS HARQ-ACK, and generates/transmits new SPS HARQ-ACK for the SPS PDSCH occasion. Similar to handling legacy missing DCI issues, gNB will check 1) whether the deferred SPS HARQ-ACK and new DG PDSCH HARQ-ACK are transmitted or 2) whether the new SPS HARQ-ACK is transmitted.  When SPS HARQ bits are dropped (no further HARQ combining is possible), HARQ-ACK feedback for the dropped SPS HARQ bits is not useful. Thus, we don’t think any further clarification or specific handling is needed. |
| vivo | DCI miss-detection is not a new ‘issue’. It can be handled by gNB’s proper scheduling/configuration or by gNB’s blind detection.  About Sony’s comments, we share the same views with moderator. The point is the newly scheduled/configured PDSCH uses the same HARQ process as the deferred SPS PDSCH. The HARQ buffer for the deferred SPS PDSCH will be flushed and this also invalidates the HARQ-ACK for the deferred SPS PDSCH. |
| CATT | Thanks moderator for the consideration and thanks all for the discussion, especially thanks to Qualcomm for the detailed replies.  We would like to further elaborate our comments by some figures which hopefully can make us clearer.  The first case we commented is that in case an SPS PDSCH occasion with same HARQ process ID as deferred SPS HARQ bit(s) is overridden by a DCI scheduling a dynamic PDSCH with a different HARQ process ID and the scheduling DCI is missed at UE side.  In addition to Qualcomm’s case where the HARQ-ACK for the SPS PDSCH is deferred after the SPS HARQ-ACK for a later SPS PDSCH occasion with the same HARQ process ID, there is another case as shown below. The target slot for SPS HARQ-ACK is before the later SPS PDSCH occasion with the same HARQ process ID, but the HARQ-ACK in the target slot is triggered to be retransmitted after the SPS PDSCH occasion with the same HARQ process ID. If DCI is missed at UE side, UE would exclude 1-bit for the earlier SPS PDSCH in the HARQ-ACK retransmission which is different from gNB assumption.    The second case we commented earlier is that UE is scheduled to receive a PDSCH with the same HARQ process ID as the deferred SPS HARQ bit(s) and the scheduling DCI is missed at UE side as illustrated by the following figure. It seems that companies are thinking to avoid the case by gNB implementation or by gNB blind detection.    In general, if the above cases are allowed, we think the proposal from Sony is the simplest solution so that the HARQ-ACK codebook size is not impacted. From UE implementation perspective, given the valid HARQ-ACK is dropped by the UE, UE can simply feedback NACK in this case. If companies think all those cases should be avoided by gNB scheduling, it may be also fine. Then I am curious what the valid cases companies have in mind. Is it the first case above without scheduling DCI with a different HARQ process ID? |
| Samsung | We prefer simple handling (just considering only SPS PDSCH case, excluding DG PDSCH) if DCI missing issue is real problem. There is no need to introduce other specific handling in this case. |
| OPPO | We share similar view as Samsung, i.e. no specific handling in this case. |
| Panasonic | We think the gNB can avoid the HARQ-ACK collision incident by setting the proper number of SPS HARQ processes. In addition, the partial transmission of deferred HARQ-ACKs would reduce the chance of HARQ-ACK collisions. In case the UE cannot transmit all the deferred HARQ-ACKs, it can transmit those that might be collided/dropped earlier. |
| Sony | **@Moderator & vivo:** Please note, I am referring to the **HARQ-ACK bits (the UCI bits)** that are transmitted **NOT** the soft bits of the PDSCH in the SPS. **This is different the HARQ-ACK bits (UCI) are the ACK and NACK whilst the HARQ bits are the soft bits of the PDSCH**. The HARQ-ACK (UCI) of the deferred SPS can be transmitted without changes to the Codebook and I do not understand why we have to also drop the HARQ-ACK (UCI) bits of the dropped deferred SPS.  Also ***we did not propose to store soft bits in the HARQ buffer for multiple PDSCH with same HPN***, we proposed to drop an SPS that has been successfully decoded when there is a HARQ Process ID collision, that is, there are only enough HARQ buffer space to store one set of soft bits for one PDSCH and instead of always dropping the deferred SPS we drop the deferred SPS if it has been successfully decoded otherwise we drop the non-deferred SPS.  We have already clarified this but somehow companies just ignored our clarification. Due to such confusion, we have to object to the WA so that the confusion is cleared (sorry). |

**Before getting more input on question 2.3, let’s leave proposal CP2.2 unchanged. Supporting companies combined from email & drafts folder, CATT objection included (with yellow, let’s see how the discussion**

**Proposal CP2.2: For SPS HARQ-ACK deferral, confirm the RAN1#104b-e working assumption with the following updates:**

**Working assumption: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:**

* **In case the UE is expected to receive~~s~~ PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.**

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| Supporting companies | Nokia/NSB, OPPO, vivo (1st preference), Panasonic, Intel, Sharp, ZTE, Spreadtrum, TCL (1st) , Qualcomm (1st) , NEC, ETRI, China Telecom, FGI/APT, LG, Huawei, Lenovo/Motorola Mobility, Ericsson, Mediatek, Xiaomi |
| Objecting companies | Sony |

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| --- | --- |
| *Company* | *Comments* |
| Sony | We just think there is a better approach to this issue than a sledge hammer method of dropping all deferred SPS HARQ bits. However, this isn’t a big issue and most of the time we expect the SPS to be successfully decoded. Hence, we will neither support nor object. |
| QC | Reply to CATT’s cases is given above. |
| DOCOMO | We think the ambiguity issue raised by CATT is valid if DG PDSCH overrides SPS PDSCH with the same HARQ process ID. We agree with Huawei and Qualcomm that the case can be avoided by gNB implementation.  However, if avoiding by gNB implementation is the common understanding, it seems the working assumption needs to be modified into “UE doesn’t expect to receive another PDSCH with the same HARQ process ID as a deferred SPS HARQ”.  Actually we think it is also the principle in Rel-15/16 to avoid such collision. We already have K1\_def limitation which may be understood as “expected transmission” in current specification descriptions.  “The UE is not expected to receive another PDSCH for a given HARQ process until after the end of the expected transmission of HARQ-ACK for that HARQ process, where the timing is given by Clause 9.2.3 of [6].” |
| CATT | See comments above. |
| ZTE | DOCOMO’s proposal is reasonable. |
| Sony | It seemed like there is a confusion on what is dropped. Are we:   1. Dropping the SOFT BITS of the PDSCH of the deferred SPS ONLY 2. Dropping the SOFT BITS of the PDSCH of the deferred SPS and its corresponding HARQ-ACK (UCI) bits   If it is understanding 1, then we are fine albeit we think it is a poor way to handle the situation.  If it is understanding 2, we have to object as we do not see any reason to also drop the HARQ-ACK (UCI) bits. |

Looking proposal **CP2.3**, there had been comments on some modifications proposed by Ericsson which had not been captured yet. Moreover, LG objected to the proposal requested a clarification on payload size which may not be fully clear yet (requested some clarification). Moderator comment to LG: please note the target slot determination validity check (i.e. overlap with defined invalid symbols) is only for *sps-PUCCH-AN-List-r16* or *n1PUCCH-AN* (i.e. only SPS HARQ-ACK in the slot), for dynamically scheduled PUCCH the UE does not check the overlap and neither it is checked if it is to be multiplexed with CSI. So we may only need some clarification on the HARQ payload size, but not the PUCCH resource set to be used.

Both issues are tried to be accommodated with the following updates. **Companies and specifically LG please check if you are still fine with this change:**

**Mod3 Proposal CP2.3: For SPS HARQ-ACK deferral, the ~~next available PUCCH (i.e.~~ target PUCCH slot~~)~~ is defined as the next PUCCH slot where ~~earlier of~~ *sps-PUCCH-AN-List-r16* or*n1PUCCH-AN* PUCCH resource is regarded as valid*,*or a ~~dynamically indicated~~PUCCH resource*(from PUCCH-ResourceSet, i.e. DG PDSCH HARQ multiplexed*) is dynamically indicated**

* **The target PUCCH slot determination is based on the total HARQ-ACK payload size including deferred SPS HARQ-ACK information and non-deferred HARQ-ACK information (if any) of a candidate target PUCCH slot ~~cell definition takes the HARQ-ACK multiplexing in the target PUCCH slot into account~~**
* **The final PUCCH resource selection in the target PUCCH slot in terms of PUCCH resource set and PUCCH resource ID follows the Rel-16 procedures.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, vivo, Panasonic, Intel, Sharp, ZTE, DOCOMO, Samsung, ETRI, CATT, China Telecom, FGI/APT, Huawei, Lenovo/Motorola Mobility, NEC, QC, Spreadtrum, OPPO, Sony, CATT, LG, Xiaomi |
| Objecting companies |  |

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| --- | --- |
| *Company* | *Comments* |
| LG | Fine with updated proposal. Thanks for the consideration. |
| ZTE | @ FL. Just for confirmation: For target PUCCH slot determination, UE should not consider the DCI for DG PUCCH, as when UE determines the target slot, UE doesn't make sure that it could have a DCI for DG PUCCH, also the time of UE determination is up to UE implementation. And then “**PUCCH resource*(from PUCCH-ResourceSet, i.e. DG PDSCH HARQ multiplexed*) is dynamically indicated**” in main bullet means if there is a DG PUCCH in the target PUCCH slot, UE just considers multiplexing SPS HARQ (including deferred and new)with the dynamic HARQ information, is it the right understanding?  Moderator: The procedure logically to moderator is done in the following way, when checking if a PUCCH slot could be the target slot:   1. If there is a scheduled PUCCH (from PUCCH-ResourceSet, i.e. DG PDSCH HARQ-ACK multiplexed), the slot is used as determined target slot and SPS HARQ is to be multiplexed on the PUCCH. This is independent of any further checking of valid/invalid symbols that we defined earlier. 2. If (1) does not apply (i.e. SPS HARQ-ACK only, no DG PDSCH HARQ-ACK in a slot), the UE checks the validity from the SPS resource set based on the SPS HARQ-ACK payload size using the defined invalid / valid symbols. If this PUCCH is regarded as ‘valid’, the slot is determined as target PUCCH slot    * If no CSI, the SPS HARQ-ACK is using SPS PUCCH config. As explained, there could still be the case that the UCI cannot be transmitted (such as SFI, DL grant overlapping, UL CI when mux on PUSCH)    * If there is also CSI in the slot, the multi-CSI config is used. There may be collision of this PUCCH resource with SS-DL symbols still (but this is the same condition as in the initial slot, also there no deferral). And again, there could be SFI & DL assignment limiting usage of SS-FL symbols and UL CI affect. |
| Sony | Based on the clarification, in Proposal CP2.4, I would like to clarify further what is meant by “regarded as valid” in Proposal CP2.3 as follows:  **For SPS HARQ-ACK deferral, the ~~next available PUCCH (i.e.~~ target PUCCH slot~~)~~ is defined as the next PUCCH slot where ~~earlier of~~ *sps-PUCCH-AN-List-r16* or*n1PUCCH-AN* PUCCH resource is regarded as valid*,*or a ~~dynamically indicated~~PUCCH resource*(from PUCCH-ResourceSet, i.e. DG PDSCH HARQ multiplexed*) is dynamically indicated**   * **The target PUCCH slot determination is based on the total HARQ-ACK payload size including deferred SPS HARQ-ACK information and non-deferred HARQ-ACK information (if any) of a candidate target PUCCH slot ~~cell definition takes the HARQ-ACK multiplexing in the target PUCCH slot into account~~** * **A next PUCCH slot is regarded as valid if the PUCCH can be transmitted based on semi-static slot format configurations** * **The final PUCCH resource selection in the target PUCCH slot in terms of PUCCH resource set and PUCCH resource ID follows the Rel-16 procedures.**   Moderator: The procedure logically to moderator is done in the following way, when checking if a PUCCH slot could be the target slot:   1. If there is a scheduled PUCCH (from PUCCH-ResourceSet, i.e. DG PDSCH HARQ-ACK multiplexed), the slot is used as determined target slot and SPS HARQ is to be multiplexed on the PUCCH. This is independent of any further checking of valid/invalid symbols that we defined earlier. 2. If (1) does not apply (i.e. SPS HARQ-ACK only, no DG PDSCH HARQ-ACK in a slot), the UE checks the validity from the SPS resource set based on the SPS HARQ-ACK payload size using the defined invalid / valid symbols. If this PUCCH is regarded as ‘valid’, the slot is determined as target PUCCH slot    * If no CSI, the SPS HARQ-ACK is using SPS PUCCH config. As explained, there could still be the case that the UCI cannot be transmitted (such as SFI, DL grant overlapping, UL CI when mux on PUSCH)    * If there is also CSI in the slot, the multi-CSI config is used. There may be collision of this PUCCH resource with SS-DL symbols still (but this is the same condition as in the initial slot, also there no deferral for that case). And again, there could be SFI & DL assignment limiting usage of SS-FL symbols and UL CI affect.   Please note that the additional sentence you propose may have some further clarification need (in terms of SS-FL symbols utilization). We defined invalid/valid symbols already for the target slot, and these only apply when there only SPS HARQ (but no CSI, or DG PDSCH HARQ) is present in a slot. As explained also in 2. above, if there is CSI in the target slot, this may not be valid any longer. |
| Huawei | We are fine in principle.  In addition, for the 1st bullet I guess the intention is: the target PUCCH slot is determined based on the total HARQ payload including deferred SPS HARQ-ACK **if any**, and the non-deferred SPS HARQ-ACK **if any**, so I try to make minor modify as below:  **The target PUCCH slot determination is based on the total HARQ-ACK payload size including deferred SPS HARQ-ACK information (if any) and non-deferred HARQ-ACK information (if any) of a candidate target PUCCH slot ~~cell definition takes the HARQ-ACK multiplexing in the target PUCCH slot into account~~**  Moderator: OK with the second (if any) and implemented, but not the first one. If there is no deferred SPS HARQ-ACK information, there cannot be a ‘target slot’ as we define it to contain deferred HARQ-ACK information. |
| QC | Same understanding as ZTE (hence, answer, yes). Agreement with Huawei’s wording and the second “(if any)”-not the first one. |
| Lenovo/Motorola Mobility | Fine with the proposal. Regarding Huawei’s comment, we think deferred SPS HARQ-ACK information always exists in the target PUCCH slot. So, the suggested modification is shown in green:  **The target PUCCH slot determination is based on the total HARQ-ACK payload size including deferred SPS HARQ-ACK information and non-deferred HARQ-ACK information (if any) of a candidate target PUCCH slot.** |
| vivo | Same views as Lenovo/Motorola Mobility. |
| CATT | Fine with the update from Lenovo/Motorola Mobility. |
| Moderator | Sorry last week to implement the ‘if any’ now done. |
| Sony | @Moderator: I think you just explained the extra bullet I added that dynamic SFI does not play a role in determining the target PUCCH/slot. So why would my addition cause confusion? I do not understand why my addition would require further clarification of FL symbols. The addition just say that the target PUCCH/slot is determined using semi-static information of the slot format. |

**On proposal CP2.4**, there has been some confusion on the brackets, which resulted in the fact of Sony objecting. As discussed, there could be different reasons that, namely SFI, dynamically scheduled PDSCH, with UCI on PUSCH based on UL CI indication just to name a few. Maybe it would be therefore better, to not try to list all possible cases here, but just have the statement without the brackets (which seems to cause more confusion than helping the understanding). **Sony please check. As a consequence, the following update is proposed. Earlier supporting companies, please check if you are still supporting the proposal also with this update**:

**Modified Proposal CP2.4: For SPS HARQ-ACK deferral, if after the target PUCCH slot determination the deferred SPS HARQ-ACK cannot be transmitted ~~(e.g. due to SFI indication or due to slot format change resulting in new collision with DL)~~, the deferred SPS HARQ-ACK bits are not further deferred and are dropped.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Intel, Sharp, DOCOMO, CATT, China telecom, NEC, Huawei, Ericsson, LG, Spreadtrum, Mediatek, Lenovo/Motorola Mobility, Samsung |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Sony | Thanks the FL & others for the clarification. Sorry didn’t mean to be the sole objecting company but I do need clarification.  At least my confusion is on the definition of target PUCCH slot as the UE would have made the checks before calling it a target PUCCH slot. Let’s take an example below, SFI#1 indicate a slot format for Slot *n* to *n*+4 as below, that is in Slot *n*+1 and Slot *n*+2, the FL symbols are changed to DL symbols. The PUCCH for SPS#1 P#1 is therefore dropped and so the next available PUCCH is P#2 in Slot *n*+2. Now, based on Proposal CP2.4, since SFI#1 caused P#2 to be dropped, then we cannot transmit the deferred HARQ-ACK for SPS#1 even thought we have P#3 available. Using the same argument, can we actually defer the HARQ-ACK for SPS#2 since its corresponding P#2 is dropped due to SFI#1? Hence, there is a confusion on what it is meant by target slot. Wouldn’t the UE know that a target slot/PUCCH is not really a target slot due to SFI or UL CI?    Reading the comments, I think the issue here is not SFI or UL CI but **rather a timeline issue**. That is where should this SFI#1 (UL CI) be located in time before we decide a slot as a target slot or a PUCCH is a target PUCCH. If SFI#1 in figure above is in Slot *n*+2, would we still count P#2 as target PUCCH or not? That is we should clarify:   1. **WHEN** is/can the target slot/PUCCH be determined at the UE. 2. Is there a ***cut off point*** in which case the UE can no longer determine a target slot/PUCCH? If yes, where is this cut off point? This has an impact of when the DL Grant needs to arrive before the UE can consider the corresponding PUCCH as a target slot/PUCCH.   It will be good if someone can clarify the above.  Moderator: Please note that SFI handling is not part of the target slot determination. In the determination (CP2.3), SFI is not taken into account and therefore, there is no issue in terms of timeline for the determination of the target slot.  So it can happen, that after determining the target slot (i.e. determination is done), there could still be cases that the deferred HARQ-ACK cannot be transmitted, such as due to SFI, DL grant, UL CI etc. But as the target slot determination is independent of the SFI (or other aspects), there is no timeline issue for the target slot determination. The timeline issue would only become a problem, if SFI, DL assignment or UL CI is taken into account in the target slot determination – which is not the case.  I hope this clarifies.  Thanks for the clarification. Basically the example in the figure above says that the HARQ-ACK for SPS#1 is not deferred and is dropped. Is that the right understanding?  On the DL Grant aspect, the proposal in CP2.3 suggested that the target slot/PUCCH takes into account the dynamically scheduled PUCCH. So how would this work if the understanding says that dynamically grant is not taken into account in determining target PUCCH?  Also can we clarify in CP2.3 that SFI and UL CI are not taken into account or rather only semi-static slot formats are taken into account.  Moderator: Please see my further comments to CP 2.3. We just have the same handling as in the initial slot. Also there can be cases that the HARQ-ACK is dropped due to different (and the same) reasons.  Just for my clarification, in my example above, the dropping of PUCCH P#1 will NOT lead to the HARQ-ACK being deferred because the dropping is caused by SFI. Is that right? If yes, I think it is worth clarifying. |
| QC | Is the intention of this proposal to capture the following case?   1. SPS HARQ collides with DL and it is deferred 2. UE fins “target slot” for deferred SPS HARQ according to CP 2.3 (for simplicity, let’s ignore new UCI, hence one PUCCH resource in ***sps-PUCCH-AN-List-r16* or*n1PUCCH*** is available in this slot). This available PUCCH resource is on flexible symbols 3. Network sends SFI or dynamically schedules DG PDSCH on these flexible symbols on which the PUCCH from ***sps-PUCCH-AN-List-r16* or*n1PUCCH*** is.   In this case the network indicates that the network indicates that the network does not want to have the deferred SPS HARQ bits. Is this what is attempted here? If yes, this is a part of the story. The network might still want the bits but due to higher priority traffic sends this SFI or DG. Therefore the group should decide if  SPS HARQ deferral should be configured when SPS PUCCH is scheduled on flexible symbols.  Suggest that the moderator highlights this issue as an open issue for the next meeting so that companies can think further. |
| Lenovo/Motorola Mobility | Okay with the updated proposal. |
| vivo | We are fine with the updated proposal. |
| CATT | Fine with the modified proposal. |
| Sony | I have similar questions as QC’s (not exactly but similar). So what is the deal with SPS PUCCH on FL symbol? If it is changed to DL by SFI is the HARQ-ACK for this dropped SPS PUCCH deferred or not? |

On **proposal CP2.7** to not optimize the Type 1 HARQ-ACK codebook for deferral (i.e. use common handling), Huawei was willing to compromise and remove an earlier objection, but the objection by vivo was still available. **Considering the large support for this proposal, moderator would like to ask vivo to re-think their position. Proposal is changed and supporting companies from the 1st check-up still shown as supporting**:

**Proposal CP2.7: For SPS HARQ-ACK deferral, in the target PUCCH slot the deferred SPS HARQ-ACK bits are appended to the initial HARQ bits / Type 1 or Type 2 codebook.**

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| Supporting companies | Nokia/NSB, OPPO, Panasonic, Sony, Intel, Sharp, DOCOMO, TCL, Qualcomm, ETRI, NEC, CATT, China Telecom, LG, Lenovo/Motorola Mobility, Ericsson, Samsung, Huawei, **vivo,** Xiaomi |
| Objecting companies |  |

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| *Company* | *Comments* |
| vivo | Thanks a lot moderator’s efforts. OK, we can accept the proposal for the sake of progress. |
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**Other**

The answers on Question 2.5 on total payload size not fitting the target slot, from the first round have been rather diverse over the options. Going from not an issue, payload size should be large enough (Alt. 4), over simple deferred SPS HARQ-ACK dropping (of Alt. 3) or more joint deferral (of Alt. 1) to optimization of latency by supporting (of Alt. 2).

The argument of companies of Alt. 4 is that the PUCCH resources can be configured by the gNB to be very large and gNB can take care of that and there is no need to over-specify the feature overall.

The moderator has some sympathy for this, so maybe let’s see if we could try to converge on Alt. 4 (please note, the wording may not be perfect, suggestions on better wording appreciated).

**Modified Proposal 2.4.1: For HARQ-ACK deferral, the UE does not expect the total UCI payload size in the target PUCCH slot ~~cell~~ to exceed the maximum payload of the PUCCH configuration(s).**

Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.

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| --- | --- |
| Supporting companies | Nokia/NSB, NEC, Samsung, DOCOMO,Xiaomi, Spreadtrum,TCL, CATT, vivo, ZTE, Intel, Huawei, Lenovo/Motorola Mobility |
| Objecting companies | China Telecom, Panasonic |

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| --- | --- |
| *Company* | *Comments* |
| QC | It is too early to adopt such a proposal. As discussed in Question 2.3 also, it is important to separate the 2 cases”  Case 1: CSI is also deferred  Case 2: CSI is not deferred.  The same separation applies with regards to defer HARQ bits multiplexing with new CSI in the target slot. |
| OPPO | Alt 2 can be a simple scheme with smaller spec effort. It leaves flexibility for gNB and transmits SPS HARQ-ACK as much as possible.  Alt 2 has the largest number of proponents, so it’s not reasonable to exclude Alt 2. |
| China Telecom | Considering an example where there are many DL slots before a semi-static flexible slot, then followed by UL slot(s), SPS periodicity is short and K1 is configured to 1 slot, thus multiple SPS HARQ-ACK need to be deferred. The Proposal has restriction no configuration of PUCCH resource which could only accommodate a small number of bits in the several UL symbols of the semi-static flexible slot. Otherwise if it is configured, the flexible slot would be the target slot but can not accommodate all the deferred SPS HARQ-ACK.  On the other hand, if multiple UL slots have SPS PUCCH resource, and there is no UCI other than the multiple deferred SPS HARQ-ACK to be transmitted on the first of the UL slots, does the proposal require the SPS PUCCH resource configured in each UL slot large enough to accommodate the multiple deferred SPS HARQ-ACK？ |
| Panasonic | Waiting for PUCCH resources with large payload size may lead to a additional delay for transmitting deferred HARQ-ACKs. It is beneficial to transmit even part of available deferred HARQ-ACKs using PUCCH resources with smaller payload size. |
| Sony | We share similar with OPPO, that there are sufficient companies who are interested to explore partial deferral, i.e. Alt-2. |
| Huawei | Though our 1st preference is Alt.1, we can live with Alt.4 for simplicity. But I guess the situation is not ‘the maximum payload’ of the target PUCCH is exceeded, but the target slot cannot accommodate the PUCCH determined based on the total UCI payload. Thus we try to modify as below:  **For HARQ-ACK deferral, the UE does not expect the PUCCH determined by the total UCI payload size cannot be accommodated in the target ~~PUCCH cell~~ slot ~~to exceed the maximum payload of the PUCCH configuration(s)~~.**  **Moderator comment:** we need to be slightly careful with this formulation to say the PUCCH cannot be accommodated in the target slot, as there could still be UCI dropping in the target slot (e.g. SFI).Change from cell to slot taken |
| Apple | We support the proposal |
| Moderator for round 3 | Trying to ‘explore’ something after more than a year into the WI phase is of course always possible. Please note, that if there is no agreement on this (and not captured in the specifications) this is to be regarded as an error case. |
| QC | The motivation and the rush to agree on this is unclear. Is the intention to capture the fact that gNB configured the maximum possible UCI payload? And if not, deferral is treated as an error case? Isn’t it the same end result as if nothing is specified? |

* 1. 4th Round of email discussions

**HARQ process collision:**

DoCoMo raised the question, if there can be actually any HARQ process collision, based on the following specification text:

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| “The UE is not expected to receive another PDSCH for a given HARQ process until after the end of the expected transmission of HARQ-ACK for that HARQ process, where the timing is given by Clause 9.2.3 of [6].” |

**But if this is to be interpretated, that dropped HARQ-ACK would cause the PDSCH usage of this HARQ-ACK process to be stalled, then based on the Rel-16 operation, a single dropped of SPS HARQ-ACK would basically block the corresponding HARQ-ACK process indefinitely? Please note that in**

So let’s quickly check if companies have the same understanding on the Rel-16 operation first:

**Question 2.5.1: Do you agree, that based on R16 running specifications, that dropped SPS HARQ-ACK (e.g. due to collision with semi-static DL symbols) is regarded as ‘the expected transmission of HARQ-ACK’ in the following specification text?**

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| “The UE is not expected to receive another PDSCH for a given HARQ process until after the end of the expected transmission of HARQ-ACK for that HARQ process, where the timing is given by Clause 9.2.3 of [6].” |

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| --- | --- |
| Yes | Nokia/NSB, DOCOMO, vivo, Samsung, Xiaomi, OPPO, Sony, Intel, Lenovo/Motorola Mobility, LG, ZTE, Spreadtrum, NEC, CATT |
| No |  |

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| --- | --- |
| *Company* | *Comments* |
| DOCOMO | HARQ process blockage is not preferred. We think the “expected transmission” without deferral consideration represents the HRQ-ACK timing indicated by K1. If taking SPS HARQ-ACK deferral into account, we can understand/extend it as “the latest HARQ-ACK timing restricted by maximum deferral limitation”. |
| vivo | From the spec, our understanding is that regardless of the HARQ-ACK for a SPS PDSCH or dynamic PDSCH with a given HARQ process is transmitted or dropped due to some reasons, the initial/original HARQ-ACK feedback timing for this SPS PDSCH or dynamic PDSCH is still used as reference to define the time requirement for receiving another PDSCH (SPS or dynamic PDSCH) with the same HARQ process.  The dropped HARQ-ACK will not cause the PDSCH usage of this HARQ process to be stalled. |
| Samsung | Although this transmission is finally cancelled due to semi-static DL symbols, this sentence has been considered in order to provide back-to-back transmission for relaxing UE processing. |
| Xiaomi | We have the same understand about “expected transmission” with DOCOMO |
| Sony | How does the gNB ensure there is no collision? In Rel-16, gNB sets the K1 value but each SPS but here we effectively extended this K1 value to *k1def*, which is may be slightly more challenging.  However, it will be good for gNB to ensure collision doesn’t happen and so we agree with Question 2.5.1. It would also be beneficial if we formally conclude this clause (i.e. as a conclusion written in Chairman notes) so that the editor can take this into account. |
| Intel | Same understanding as Samsung |
| Lenovo/Motorola Mobility | In our view, the above mentioned Rel-16 spec is not relevant to a HARQ process that has the deferred SPS HARQ-ACK. |
| LG | Agree. Regardless of how we use the text, we think that “expected transmission” can be interpreted as timing based on its scheduling. Similar to Samsung’s view, we also think the sentence has been considered as a reference timing for each HARQ process. At least, SPS HARQ-ACK deferral is not predictable. |
| Spreadtrum | Not matter the HARQ-ACK for a SPS PDSCH is dropped or deferred, the original HARQ-ACK feedback determines the reference timing for the HARQ process. |
| QC | Agreement with Lenovo/Motorola: the sentence above is written without having deferral in mind. If the wish is to check the validity of this sentence to the case of SPS HARQ deferral, then, DoCoMo’s interpretation is the one supported. |
| NEC | Agree. In our understanding, for deferred SPS HARQ-ACK, the “ expected transmission of HARQ-ACK” of means the original PUCCH transmission determined based on the HARQ-ACK timing k1 rather than the actual PUCCH transmission determined based on k1+k1def. |
| CATT | We share the same understanding as DOCOMO. |

Now on the working assumption, there had been some discussions that gNB can prevent such collision, which is somehow against the spirit when the working assumption was taken. The arguments at that time had been, that for SPS with short periodicities such collision may be happening regularly, if gNB would not e.g. by DG PDSCH overriding prevent them. But then, this is then somehow against the idea of the SPS HARQ-ACK deferral, as the DG PDSCH could have been used to prevent the HARQ-ACK dropping in the first place.

So before trying to confirm the ‘modified working assumption’, lets check if companies have the same understanding:

**Question 2.5.2: Which of the following do you prefer:**

* **Alt. 1: HARQ process collision in the SPS deferral should be avoided by gNB implementation, e.g. by using DG PDSCH overriding to prevent SPS to SPS HARQ process collision.**
* **Alt. 2: Adopt the ‘modified working assumption’ (in principle) on the HARQ process collision and do not rely on DG PDSCH overriding SPS PDSCH and DG PDSCH HARQ-process selection to prevent related HARQ process collision due to SPS HARQ-ACK deferral.**

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| --- | --- |
| Alt. 1 | Sony, Lenovo/Motorola Mobility, ZTE |
| Alt. 2 | Nokia/NSB, DOCOMO, vivo，Xiaomi,OPPO, Panasonic, LGy, NEC |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia, NSB | If we leave the handling to gNB, for short periodicities there would be a need for regular DG PDSCH overriding SPS PDSCH. This somehow would defeat the idea behind the SPS deferral, as otherwise DG PDSCH could have been used initially to prevent the SPS HARQ-ACK dropping. |
| DOCOMO | HARQ process collision between SPS PDSCHs can be avoided by proper maximum deferral limitation, , but not relying on DG PDSCH overriding SPS PDSCH.  DG PDSCH HARQ process collision can be avoided by gNB implementation. |
| vivo | One Typo in Alt.2, **DG P~~U~~DSCH HARQ-process.**  Alt.2 is preferred. Alt.1 would add scheduling restrictions on gNB side, always rely on DG PDSCH override SPS PDSCH is not an efficient solution. In addition, it may be hard to totally avoid HARQ process collision by gNB implementation for the case when more than one SPS Config are configured with small periodicity. |
| Samsung | In previous round discussion, most of companies have provided there is no special handling on the case where DG PDSCH overriding SPS PDSCH for HARQ process collision. But, some companies want to clarify the issue and need some specific handling to resolve this issue. In this sense, we would like to confirm working assumption with narrowing down the case considering only SPS PDSCH and excluding DG PDSCH for minimum specification impact as follows.   * *In case the UE ~~receives~~ is configured to receive a PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.*   We are also open to confirm original working assumption conditionally by adding a note such as  Note: there is no further discussion on specific handling the case where DG PDSCH is overriding SPS PDSCH. |
| Sony | This is rather contradictory for those who answered “Yes” to Question 2.5.1 but prefer Alt-2 in Question 2.5.2. In Question 2.5.1, it suggested that the gNB would take care of this and stop same HPN collision because the UE doesn’t expect such collision but in Question 2.5.2, we suggest UE need to expect such collision and to do something about it, i.e. drop the deferred SPS. |
| Intel | Alt.1 looks like an inefficient work-around, and we should strive solving the issue more efficiently. Alt.2 is then preferred. |
| Lenovo/Motorola Mobility | If HARQ process collision occurs regularly due to short SPS periodicities and/or a small number of HARQ processes assigned for SPS, SPS HARQ-ACK deferral may not be beneficial. gNB implementation should ensure proper SPS configurations and use DG PDSCH overriding whenever needed. |
| LG | We prefer Alt. 2 and we are fine with Samsung’s suggestion.  gNB can schedule PDSCH for a new transmission instead of deferred SPS HARQ-ACK, however, it is not reasonable to impose such handling on gNB. |
| ZTE | Maybe the consequences of the 2 alternatives for UE are the same that the SPS HARQ bits will be not transmitted if the overriding in Alt.1 is applied. Slightly prefer Alt.1. |
| Qualcomm | Agreement with NTT DoCoMo: HARQ process collision between SPS PDSCHs can be avoided by proper maximum deferral limitation, but not relying on DG PDSCH overriding SPS PDSCH.  DG PDSCH HARQ process collision can be avoided by the gNB implementation performing the obvious task: not allocating DG PDSCH HARQ on DL symbols.  As also mentioned by Lenovo/Motorola Mobility the case mentioned by the moderator is not valid. Therefore, the modification of the text “the non-justified “argument”” provided by the moderator and the whole discussion, i.e. the changes at  “. The arguments at that time had been, that for SPS with short periodicities such collision may be happening regularly, if gNB would not e.g. by DG PDSCH overriding prevent them.”  Is a result of a confusion. E.g. if the network has so many opportunities to schedule DG PDCSH so freely, why SPS is used? Especially knowing that SPS PUCCH will collide with DL.  The group keeps on discussing topics of very limited relevance.  The other not-justifiable question is that companies suggest that HARQ Process ID collision is avoided by gNB implementation. What is suggested to set appropriately a network timer/parameter, which is the maximum deferral time, so as this HARQ Process ID collision is avoided.  Moderator: it is not up to the companies to change the main text here. If you think you want to comment please do so. BUT DO NOT CHANGE the main text or any proposals, as otherwise, the discussions and inputs by companies given earlier may not be reflected correctly! Reverted back to initial text before the question! |
| NEC | For HARQ process collision between SPS PDSCHs, it seems hard for gNB can always avoid such collision by using DG PDSCH overriding SPS PDSCH. |
| CATT | A fundamental problem we have is the impact on the HARQ-ACK codebook size in the subsequent transmission after SPS HARQ-ACK is dropped due to missed DCI. More details can be found in our earlier reply. In order to resolve our concern, we see two possible alternatives:  **Alt. 1:** Similar as what proposed by Samsung, we consider SPS PDSCH only. Furthermore, we can exclude the SPS PDSCH(s) which are not required to be received among a group of overlapping SPS PDSCH(s) according to TS38.214 clause 5.1. The proposed updated WA is as follows. The intention is to determine the dropped SPS HARQ bit(s) based on semi-static configurations only so that gNB and UE would have the same understanding.  **For SPS HARQ-ACK deferral, confirm the RAN1#104b-e working assumption with the following updates:**  **Working assumption: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:**   * **In case the UE is required~~expected~~ to receive~~s~~ a SPS PDSCH of a certain HARQ Process ID according to TS38.214 clause 5.1, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.**   **Alt. 2:** Confirm the modified working assumption and for UE feedback NACK for a SPS PDSCH whose HARQ-ACK bit is dropped.  The idea of Alt. 2 is that the subsequent HARQ-ACK codebook size is not impacted due to missed DCI. |

Sony raised the issue, that they would be fine with soft buffer flushing the buffer but not with dropping the HARQ-ACK (even tough there is no PHY re-transmission possibility any longer, as the soft-buffer had been flushed).

So let’s get feedback also on this:

**Question 2.5.3: In case of HARQ process collision due to SPS HARQ-ACK deferral,**

* **Alt. 1: the UE flushed its soft-buffer and drops the related A/N information of deferred SPS HARQ processes**
* **Alt. 2: the UE flushed its soft-buffer ~~and~~ but keeps the related A/N information of deferred SPS HARQ in its memory to be able to transmit the deferred SPS HARQ-ACK information later**
  + **Note: even though the A/N information is provided with Alt. 2, HARQ-ACK re-transmission is not possible as the UE soft-buffer had been flushed.**

|  |  |
| --- | --- |
| Alt. 1 | Nokia/NSB, DOCOMO, vivo, Samsung,Xiaomi,OPPO, Intel, Lenovo/Motorola Mobility, Huawei/Hisi, Panasonic, LG, ZTE, QC, NEC, Apple |
| Alt. 2 | Sony |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia, NSB | We see no value in keeping HARQ A/N information, but having no soft bits available any longer. |
| DOCOMO | It seems Alt 1 is more reasonable since UE may not be able to keep the A/N information for the flushed PDSCH. |
| vivo | Not sure how Alt.2 can work, since the HARQ process is now occupied by the other/new PDSCH, the HARQ-ACK feedback should corresponding to the new PDSCH. In addition, it’s not meaningful to keep the related A/N information while the corresponding soft-buffer has been flushed.  One **modification** (delete and) for above Alt.2: “**Alt. 2: the UE flushed its soft-buffer ~~and~~ but keeps”** |
| Samsung | Alt. 2 provides more complexity of UE implementation since soft-buffer and related A/N information should be separately controlled. |
| Xiaomi | Alt 1 is more reasonable. |
| OPPO | Alt 2 requires additional buffer to reserve related A/N information and increase implementation complexity and cost. |
| Sony | We expect most of the time the SPS PDSCH will be successfully decoded and hence there is no need for retransmission and hence it doesn’t matter if the soft buffer is flushed or not. However, if the UE drops the “ACK” for such successful decoding, this would lead to unnecessary retransmission from the gNB.  It isn’t clear why this would be complex since the UE would have already generated the “ACK/NACK” and the existing Codebook for multiple SPS HARQ-ACK is independent of HPN. Hence, why does the UE wants to keep the decoding outcome a secret from the gNB? |
| Intel | There is small value in receiving the HARQ-ACK corresponding to the flushed HARQ process, thus Alt.1 looks natural to us. |
| Lenovo/Motorola Mobility | Alt 2 causes redundant HARQ-ACK transmission. There will be no ambiguity regarding a HARQ-ACK codebook size, since gNB will determine whether DCI for overriding DG PDSCH (if any) is missed by UE, based on multiple hypotheses for PUCCH detection. |
| LG | Alt. 1 is more aligned with current situation. Alt. 2 would be useful when SPS occasion is dropped due to HARQ process collision. |
| QC | Alt 1,  agreement with other companies’ arguments, especially Samsung’s on complexity. The complexity increases on both UE and network sides, since both peers must store in multiple buffers data the same HARQ Process ID and index them.  A secondary note: the OOO HARQ is marginal case in the already marginal case of SPS PUCCH collision with DL. There are more important topics to be discussed in this complicated topic of SPS HARQ deferral, such as the topic of UE counting on reading SFI for SPS HARQ deferral (the moderator avoids bringing the topic with the argument “the group will not discuss UE behaviour for SFI”, but companies keep on asking if SPS HARQ deferral can be activated in cases SPS PUCCH is scheduled on flexible symbols whose behaviour depends on SFI.) The topic should be brought for discussion in the next meeting. |
| NEC | Alt.1 is simple and straightforward. We understand the intention of Alt.2 to reduce the unnecessary SPS PDSCH retransmission due to ACK dropping, but we are not clear how Alt.2 work, UE may need to store two A/N values for a same HARQ process ID simultaneously, one for deferred SPS HARQ-ACK, another one for new SPS PDSCH/DG PDSCH? |
| CATT | See our comments to Question 2.5.2.  We think the fundamental question is that whether the HARQ-ACK bit is included in the subsequent HARQ-ACK codebook or not. For Alt. 1, it is our understanding that although A/N is dropped, it can be included in the subsequent HARQ-ACK codebook and UE simply feedback NACK. |
| Sony | It still isn’t clear why it is high complexity for the UE to feedback the ACK/NACK of the dropped SPS considering in MIMO this is not an issue (and we are unlikely to do MIMO in SPS URLLC). **Again, there is NO storing the soft bits in the HARQ buffer for two PDSCH of the same HPN (as QC’s assumed).** We are talking about the HARQ-ACK (UCI bits) NOT the soft bits for PDSCH.  Also the HARQ-CB for multiple SPS does NOT take into account the HPN number (this is NOT Type 3 CB). So why is it an issue to send the ACK/NACK? |
| Sony | We suggest to agree to the original WA but discuss the issue about sending the corresponding ACK/NACK for the dropped deferred SPS later (next meeting). |

**Interaction of SPS deferral and PUCCH carrier switching:**

Now that we have a bit better understanding on the operation of those two features maybe we could at least start discussing a bit on this as well (although we may not be able to have any conclusions on this in this meeting). Please note, that it may be worth looking at the two flavors of PUCCH carrier switching separately.

**Question 2.5.4: Do you support the joint operation of SPS HARQ-ACK deferral and PUCCH carrier switching based on dynamic indication in Rel-17?**

|  |  |
| --- | --- |
| Yes | Panasonic, LG, NEC |
| No | DOCOMO, Xiaomi, Sony, ZTE, QC, Apple |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| DOCOMO | In our understanding, SPS HARQ-ACK deferring targets for HARQ-ACK dropping issue and it surely increases latency. However, PUCCH carrier switching targets for latency reduction, which seems contradicted to SPS HARQ-ACK deferring. Therefore, we don’t prefer to have joint operation of the two schemes. At least we can de-prioritize the discussion for the joint operation.  On the other hand, not sure how dynamic PUCCH carrier switching can apply to deferred SPS HARQ-ACK? Is the intention to discuss the case when deferred SPS HARQ-ACK multiplexing with dynamic HARQ-ACK with PUCCH cell indication? |
| vivo | We are open for discussion. |
| Samsung | Mixing two features have very marginal benefits while it needs further specification impact/potential UE impact. Even though target cell indicated by a DCI can be fixed for SPS HARQ ACK deferring, active cell can be changed via other DCI, and it may need to do further clarification for example if a UE may have other DCI to indicate other cell than originally indicated cell for deferring SPS HARQ. In multiple SPS operations, it is possible that more than two DCI indicates different carrier for HARQ-ACK transmission. Without considering deferring, it can be handled by gNB implementation. However if deferring is considered, it seems to be more complex to control from gNB side. |
| Xiaomi | They are two separate schemes with different functions for HARQ-ACK dropping issue, it is better not to do the joint operation. |
| OPPO | We’d better to consider this issue after SPS HARQ-ACK deferral and PUCCH carrier switching procedures are completely clear. |
| Intel | There is some motivation and scenarios for joint operation, e.g. when instead of deferring a HARQ-ACK the carrier may be switched w/o causing latency. However, we are fine to leave this operation undiscussed explicitly and see a bit later how it inter-operates. |
| Huawei/Hisi | More clarifications may be needed. If both occurs, will the UE multiplex the deferred SPS HARQ-ACKs with the DG HARQ-ACK on the indicated carrier? |
| Panasonic | It is not clear what kind of schemes are considered here. We are open for the discussions. |
| LG | We are open to discuss. Currently, it is already agreed to defer SPS HARQ-ACK based on PUCCH scheduled by DCI. It may be considered to use PUCCH in switched cell as target PUCCH. It would be better to discuss after two of features are more completed. |
| ZTE | SPS HARQ-ACK deferral is not dynamic scheduled, how to handle PUCCH carrier switch based on dynamic indication? |
| QC | Although we support the joint operation of the features, we share the concerns of other companies, that it might be better to wait till both features are specified fully, or at least when the features are close to be finalized. |
| NEC | Considering the dynamic PUCCH carrier switching is only applicable to DG HARQ-ACK, SPS HARQ-ACK deferral can be as a supplementary for SPS HARQ-ACK dropping, so it is beneficial to support the joint operations of SPS HARQ-ACK deferral and dynamic PUCCH carrier switching. |
| CATT | We prefer to discuss the joint operation later. |

**Question 2.5.5: Please describe below, your intended operation mode of joint operation of SPS HARQ-ACK deferral and PUCCH carrier switching based on dynamic indication in Rel-17?**

|  |  |
| --- | --- |
| *Company* | *Comments* |
| LG | UE may check whether a PUCCH scheduled in different carrier exists, before SPS HARQ-ACK deferral. Or, UE may utilize a PUCCH in switched cell as target PUCCH. |
| NEC | In case the PUCCH resource on Pcell/PScell for SPS HARQ-ACK collides with DL symbols, while a DG PUCCH resource on another dynamic switched cell is located in the same slot for PUCCH for SPS HARQ-ACK, UE will multiplex SPS HARQ-ACK on the DG PUCCH resource rather than do SPS HARQ-ACK deferral. It can reduce the latency for SPS HARQ-ACK transmission. |
|  |  |
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**Question 2.5.6: Do you support the joint operation of SPS HARQ-ACK deferral and semi-static PUCCH carrier switching in Rel-17?**

|  |  |
| --- | --- |
| Yes | Nokia/NSB, vivo, Huawei/Hisi, Panasonic, LG, FGI/APT |
| No | DOCOMO ,xiaomi, ZTE, QC, Apple |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | As at a certain time (and ahead of time), the PUCCH cell is know based on the time-domain pattern this is not that different compared to stand-alone operation. |
| DOCOMO | In our understanding, SPS HARQ-ACK deferring targets for HARQ-ACK dropping issue and it surely increases latency. However, PUCCH carrier switching targets for latency reduction, which seems contradicted to SPS HARQ-ACK deferring. Therefore, we don’t prefer to have joint operation of the two schemes. At least we can de-prioritize the discussion for the joint operation. |
| vivo | To exploit full benefits of the SPS HARQ-ACK deferral and PUCCH carrier switching, and it seems no much complexity. |
| Samsung | Since it can be operated as if one serving cell is active in a given time based on semi-static configuration, there might not be substantial specification impact. However, we are okay not to consider this aspect as well since mixing two features have marginal benefits. |
| OPPO | We’d better to consider this issue after SPS HARQ-ACK deferral and PUCCH carrier switching procedures are completely clear. |
| Intel | As mentioned above, there are some use cases for that. We can consider inter-operation a bit later. |
| Lenovo/Motorola Mobility | Can consider supporting joint operation once each feature becomes more complete. |
| Huawei/Hisi | Enabling the joint operation for both is helpful to further reduce the latency. |
| LG | If two of features are configured to a UE, we think PUCCH carrier switching should be considered to find target slot for SPS HARQ-ACK deferral. |
| ZTE | Maybe we have no sufficient time to finish this issue before Rel-17 closed. |
| QC | Although supportive for the joint operation of the features, the concern is that the basic features of this WI are far from being entirely specified. |
| NEC | We are open to study whether joint operation is beneficial for some cases. |
| CATT | We prefer to discuss the joint operation later. |

**Question 2.5.7: Please describe below, your intended operation mode of joint operation of SPS HARQ-ACK deferral and semi-static PUCCH carrier switching in Rel-17?**

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | The initial slot handling is not different / the same including the rules for deferral.  For the determination of the target PUCCH slot, the same procedure applies but just looking at the at a certain time applicable PUCCH cell based on the time domain pattern. |
| vivo | Based on the configured time-domain pattern for semi-static PUCCH carrier switching, UE can determine the target PUCCH cell/carrier, then UE can find the target PUCCH slot for SPS HARQ-ACK deferral. |
| Huawei/Hisi | For the initial slot and each candidate target slot, the UE seeks the PUCCH resources on the target carrier according to the time pattern. |
| Panasonic | The deferred HARQ-ACKs could be carried with an available PUCCH resource corresponding to a later SPS PDSCH occasion. |
| LG | PUCCH carrier switching pattern is taken into account to find target slot for SPS HARQ-ACK deferral. |
| FGI/APT | Target slot determination of SPS HARQ-ACK deferral takes into account the PUCCH carrier switching pattern. |

* 1. 5th Round of email discussions

**5th Round updates: Please note, only HARQ process collision issues is updated / expanded in 5th round, but please keep commenting on the joint operation of SPS HARQ deferral and PUCCH carrier switching in Sec. 2.5.**

**HARQ process collision:**

There had been good discussions. It seems that there is a large number of companies supporting to drop the HARQ-ACK, if the soft-buffer is flushed (see responses to Question 2.5.3) so we could try to agree on confirming at least some kind of modified working assumption.

Taking some of the inputs, e.g. by Samsung to take the original WA with a node and CATT by adding some reference to Sec. 5.1 to clarify what the UE is expected to receive, the following proposal is made:

**Modified Proposal CP2.2: For SPS HARQ-ACK deferral, confirm the RAN1#104b-e working assumption with the following updates:**

**Working assumption: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:**

* **In case the UE is expected to receive~~s~~ PDSCH of a certain HARQ Process ID according to TS 38.214 Sec. 5.1, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.**
  + *Note: there is no further discussion on specific handling for the case where DG PDSCH is overriding SPS PDSCH*

|  |  |
| --- | --- |
| Support | Nokia/NSB, Samsung, CATT, TCL, vivo, OPPO, Spreadtrum, ZTE，Xiaomi, Sony (*if this is independent from Question 2.5.3*), NEC, Huawei/Hisi, Panasonic, Intel, Lenovo/Motorola Mobility, Sharp, Ericsson |
| Object |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| DOCOMO | If the intention of the proposal is only for SPS PDSCH HARQ process collision, we support the principle of the proposal. For DG-PDSCH HARQ process collision, it should be avoided by proper scheduling.  But we prefer CATT’s suggested modification by “**In case the UE is expected to receive~~s~~ SPS PDSCH**” . |
| CATT | I appreciate the efforts from FL and all the companies for the continued discussions. Although the latest working assumption is not our preference, we can accept for the sake of progress.  One comment is on the Note. We would like to modify as follows to clarify the cases that DG PDSCH is overriding SPS PDSCH. Hope it is acceptable to the group.  **Working assumption: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:**   * **In case the UE is expected to receive~~s~~ PDSCH of a certain HARQ Process ID according to TS 38.214 Sec. 5.1, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.**   + *Note: there is no further discussion on specific handling for the case where DG PDSCH is overriding SPS PDSCH with the same HARQ process ID or overlapping time domain resources*   Thanks DOCOMO for your support. One of the reasons why we accept the proposal is that we think the current proposal also allows gNB to avoid the problem we brought up earlier by avoid scheduling DG PDSCH to override SPS PDSCH. The current proposal may be more preferable from UE perspective since it is more complete. |
| QC | Agreement with NTT DoCoMo. Supportive for the case of new SPS HARQ process collision with the SPS HARQ in which deferred HARQ bits are stored. This is the only case in which the term “the UE is expected to receive” is meaningful.  The goal with this working assumption is to define the UE behaviour in an extremely unlikely situation. As also discussed at the previous rounds, the network can avoid such situations of HARQ Process collision by appropriate use of its tools, such as maximum deferral time and appropriate scheduling. This does not mean there is no solution in the specifications, and everything is left in “gNB implementation” as noted by companies. The network makes use of the tools – which are defined for this purpose, such as timers/counters, scheduling – to avoid the case described. With regards to the 2nd case mentioned by CATT in the second figure presented in the 3rd round of discussions at Question 2.4.1, difficult to see the misalignment, despite several common efforts. Here is the explanation:  Step 1: SPS HARQ collides with DL symbols  Step 2: SPS HARQ deferral triggered and the UE is searching for the 1st available PUCCH. Maximum deferral timer starts.  Step 3: gNB schedules DG PUCCH and the HARQ Process ID allocated for this DG PUCCH is the same as the SPS HARQ Process ID.  Step 4: UE cannot decode DCI for the HARQ which was going to overwrite the SPS HARQ stored in that HARQ Process.  Why would the UE drop the stored SPS HARQ stored, since DCI is not decoded?  Prior to this, step 4 could have been avoided by setting appropriately the maximum deferral time. However, even without this option, the case is very unlikely, since for the case of both DG PDSCH and SPS PDSCH there are going to be 24 (or 16 according to the interpretation) HARQ Process IDs, configured. The sweeping time over all HARQ process IDs can be quite large.  Moreover, the network can avoid Step 3 with appropriate scheduling.  CATT is welcome to comment, in case something is missed. With regards to the 1st figure of the reply in the 3rd round of discussions, it was impossible for us to understand what the case is. Could you please write the steps clearly and explain what this “HARQ retransmission” mean?  If companies insist that these are central cases in the SPS HARQ deferral feature, we can wait till the next meeting to decide this behaviour. Very likely issues – if any – are understood. In general, though, the WI approaches to its end and the basic building blocks of the SPS HARQ deferral are not yet there. We are all responsible for this. |
| vivo | We are fine with moderator’s proposal in principle. About the modification by CATT, we would be fine to add *with the same HARQ process ID.* But we are not sure why overlapping time domain resources matters here? |
| Nokia/NSB | Agree with vivo, that same HARQ process ID should be there, but there is no need to talk about overlapping resources.  So maybe the note could be changed to:   * + *Note: there is no further discussion on specific handling for the case ~~where~~ of DG PDSCH ~~is overriding SPS PDSCH~~ with the same HARQ process ID* |
| Sony | We are fine with the proposal and fine with adding the “*with the same HARQ process ID*” with the assumption that this ***agreement is independent of whether we will transmit the HARQ-ACK*** ***of the corresponding dropped deferred SPS PDSCH***. We would wish to understand the complexity that some companies suggested for transmitting a HARQ-ACK, perhaps in the next meeting. |
| CATT2 | @Qualcomm, thanks for your follow-up and questions. For the 2nd case we provided in the 3rd round discussion (copied below), it is true that UE does not drop the stored SPS HARQ since DCI is not decoded and UE would include the SPS HARQ bit in the HARQ-ACK codebook in the target slot. However, from gNB perspective, gNB expects that the SPS HARQ bit is excluded in the target slot and that is the misalignment we meant.    For the 1st case we provided in the 3rd round discussion (copied below), maybe it is not a good example since it can be decoupled from SPS HARQ-ACK deferral. The case is that the HARQ-ACK for an SPS PDSCH is expected to be transmitted in slot n but it is dropped due to e.g. collision with SFI. In slot n+k, UE is triggered to retransmit the HARQ-ACK in slot n. Between slot n and slot n+k, there is an SPS PDSCH occasion with the same HARQ process ID as the previous SPS PDSCH and gNB schedules an overlapping PDSCH with a different HARQ process ID. In this case, assuming the scheduling DCI is missed at UE side, UE would drop the SPS HARQ bit and would exclude the SPS HARQ bit in the HARQ-ACK transmission in slot n+k. However, from gNB perspective, gNB would expect the SPS HARQ bit included in the HARQ-ACK transmission in slot n+k. Although it is mainly related to HARQ-ACK retransmission but it may be also helpful to hear companies’ views.    If we consider SPS PDSCH deferral case only as shown below. The SPS HARQ for the first SPS PDSCH is deferred to be later than the second SPS PDSCH occasion with the same HARQ process ID. If gNB schedules a PDSCH overlapping with the second SPS PDSCH occasion with a different HARQ process ID and if the scheduling DCI is missed at UE side. UE would not include the SPS HARQ bit in the target slot but gNB expects the SPS HARQ bit to be included in the target slot. I hope this also clarifies why we proposed to add “*overlapping time domain resources*” in the note. |
| QC 2 | @CATT.  Appreciated the further explanation. With regards to the 2nd case mentioned in the 3rd round, the misalignement mentioned will indeed happen, but gNB can resolve this issue without difficulty.  Step 1: SPS HARQ collides with DL symbols  Step 2: SPS HARQ deferral triggered and the UE is searching for the 1st available PUCCH. Maximum deferral timer starts.  Step 3: gNB schedules DG PUCCH and the HARQ Process ID allocated for this DG PUCCH is the same as the SPS HARQ Process ID.  Step 4: UE cannot decode DCI for the HARQ which was going to overwrite the SPS HARQ stored in that HARQ Process.  Step 5: UE does not drop the deferred SPS HARQ bit.  Step 6: UE transmits only the deferred SPS HARQ bit.  Step 7: gNB expects e.g. N bits, which is the sum of M bits from new DG HARQ and L deferred bits.  Step 8: gNB receives only L deferred SPS HARQ bits (instead of N)  Step 9: gNB receives and stores the whole sub-slot or slot in which PUCCH is received  Step 10: almost certainly the amount of N (DG HARQ + deferred SPS HARQ) bits is mapped to a different PUCCH resource than the amount of L deferred SPS HARQ bits  In any case, the UE missed a DCI, the network understands that DG PDSCH has to be retransmitted. In the case you describe the network has to retransmit SPS PDSCH as well. The network can avoid the scheduling you described.  Regarding the 1st example of the 3rd round of email discussion, the example may not be valid. The group has not decided yet if SPS PUCCH should be configured on flexible symbols whose behavior is dictated by SFI. Then, the other question is if in this cases SPS HARQ deferral should be configured. Suggestion: the group should discus the need for the UE to listen to SFI in cases of SPS HARQ deferral. Then, what does it mean “In slot n+k, UE is triggered to retransmit the HARQ-ACK in slot n”? Does it mean it is deferred? |

# Retransmission of cancelled HARQ

In this section, the proposed Rel-17 enhancements on retransmission of cancelled HARQ are summarized. The following related agreements from previous meetings are available on this topic:

|  |
| --- |
| Working Assumption: For at least HARQ-ACK re-transmission:   * Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16) in Rel-17   + *Definition of enhanced Type 3 CB:*      - *The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration*     - *The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)* * Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17   + *Details are FFS* * Enhanced Type 3 HARQ-ACK CB and/or one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB are subject to separate UE capabilities |

* 1. Summary of companies input in their contributions

**Confirm the RAN1#105-5 working assumption:** CATT [9], NEC[9], Mediatek [20] (the overall WA assumption including both schemes and separate UE capabilities), DoCoMo [26]

**Enhanced Type 3 CB:**

**Size determination of enhanced Type 3 HARQ-ACK CB of smaller size based on dynamic indication or RRC configuration /activation only:**

* **RRC configuration (or activation) only (3 companies)**: Huawei/HiSi [1], Panasonic [10], ETRI [19]
  + At least based on activation/release DCI for SPS and MAC CE for activation / release of serving cells: ETRI [19]
    - Reference time for the DCI / MAC CE needed to prevent size ambiguity due to dynamic signaling: ETRI [19]
* **Dynamic selection based on indication in the triggering DCI of one of multiple (configured) Type 3 CB(s) / sizes (10 companies):** vivo [2], Nokia/NSB [3] (for triggering DCI not scheduling PDSCH, otherwise only one / first Type 3 CB triggered), Spreadtrum [5] (can schedule PDSCH at the same time), Samsung [8] (N report states, if triggered no PDSCH is scheduled and unused field indicates report state), NEC [12] (reusing HPN field to indicate set of DL HARQ processes of SPS configurations), OPPO [14], Qualcomm [16] (direct indication of requested HARQ-IDs or HARQ-IDs within an indicated time window starting t0 slots before the triggering DCI), LGE [18], Intel [21] (indicating index to a table of different attributes, for both DCI scheduling PDSCH and not scheduling PDSCH), DoCoMo [26] (apply unused fields for DCI not scheduling PDSCH)
  + Self-carrier triggering - triggering DCI on cell X triggers HARQ-ACK retransmission of HARQ processes of cell X: OPPO [14]
  + If receiving multiple triggers for the same PUCCH slot, the enh. Type 3 CB for transmission contains the union of the triggered subsets: OPPO [14]

**Differentiation between Rel-16 Type 3 HARQ-ACK CB and (at least one) Rel-17 enhanced Type 3 HARQ-ACK codebook of smaller size:**

* Based on RRC configuration: CATT [9]
* Using RNTI: ETRI [19] (if only one enhanced Type 3 CB of smaller size is supported, otherwise, can use the dynamic indication in the DCI)

**PHY priority indication in the triggering DCI of the PUCCH (and the PUCCH configuration) carrying the Type 3 CB:**

* **Yes (13):** vivo [2], Nokia/NSB [3], Ericsson [4], ZTE [6], CATT [9], Panasonic [10], FGI/APT [15], Intel [21], Interdigital [22], Apple [23], Sharp [24], DoCoMo [26], WILUS [28]
* **No: -**
* **Details:**
  + HARQ-ACK process information is mapped irrespective of corresponding latest scheduled or configured priority for each HARQ process (**8 Yes – 1x No**): vivo [2], Nokia/NSB [3], Ericsson [4], Samsung [8], CATT [9], LGE [18] (except for SPS HARQ process only CB), Intel [21], DoCoMo [26] – No: Only transmit HARQ-ACK of the indicated priority: Interdigital [22]
  + For SPS HARQ process only Type 3 CB, the codebook can be constructed based on the priority of the SPS HARQ processes: LGE [18]
  + CB construction should be studied first: ZTE [6]
  + Separate configuration on presence of CBG & NDI for LP & HP enh. Type 3 CB: FGI/APT [15], Apple [23]
  + Separate configuration of applicable HARQ process (groups) for LP & HP enh. Type 3 CB: Apple [23]
  + For a triggering DCI not scheduling PDSCH, some unused bit-field can be used to indicate the PHY priority: Interdigital [22]
    - *Moderator question/comment*: We have already the PHY priority indication field in DCI formats 1\_1 and 1\_2 (if configured), couldn’t this field be used directly for indicating the PHY priority?

**Different suggested codebooks of smaller size:**

* Subset of configured CCs (3): vivo [2], Nokia/NSB [3], OPPO [14]
* Subset of configured HARQ processes (specific to CCs) (6): vivo [2], Nokia/NSB [3], Ericsson [4]. LGE [18], Intel [21] (based on dynamic indication), DoCoMo [26]
* Only activated CCs (2): Ericsson [4], ETRI [25] (?)
* SPS HARQ processes only (4): CATT [9], NEC [12], LGE [18] (separation from DG PDSCH HARQ-ACK or Rel-16 Type 3 CB by using a different RNTI), TCL [25]
* HARQ of specific SPS configurations of configured CCs (1): NEC [12]
* HARQ-IDs within time window starting t0 prior to the triggering DCI (1): Qualcomm [16]
* Dropped HARQ-ACK processes only (1): TCL [25]

**Type 3 CB triggering using DCI format 1\_2:**

* Yes (8): Nokia/NSB [3], Ericsson [4], Samsung [8], CATT [9], Panasonic [10], FGI/APT [15], Intel [21], WILUS [28]

**Handling of HARQ-ACK information which is not mapped to the enhanced Type 3 HARQ-ACK codebook of smaller size:**

* Alt. 1: Any ‘new, initial’ HARQ-ACK information for transmission in the same PUCCH slot that cannot be mapped to the enhanced Type 3 CB of smaller size is not transmitted/ dropped: Nokia/NSB [3], Intel [21]
* Alt. 2: UE is not expecting that ‘new, initial’ HARQ-ACK information cannot be mapped to the triggered enhanced Type CB of smaller size: Intel [21]

**Inclusion of SPS release to (enh.) Type 3 CB of smaller size:** WILUS (28)

**One-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource**

**Definition of HARQ-ACK codebook to be re-transmitted:**

* **Dynamic indication in the triggering DCI of the codebook(s) to be re-transmitted** (**10**): Nokia/NSB [3] (DCI does not schedule PDSCH using relative slot offset between original HARQ slot and target slot for PUCCH retransmission using unused field), ZTE [6] (‘Solution 2’: multiple field sizes which canceled/dropped HARQ-ACK codebook(s) to be transmitted), Samsung [8] (N bit trigger field for DCI that can also scheduled PDSCH or alternatively, 1 bit trigger in DCI and no PDSCH scheduled some unused field indicates PUCCH / UL slot of CB to be re-tx), CATT [9] (slot offset between triggering DCI and dropped HARQ indicated), Panasonic [10], Lenovo/Motorola [13] (slot offset between triggering DCI and cancel HARQ codebook and number of cancelled HARQ-ACK codebooks for re-transmission), LGE [18] (… indicate an UL slot and priority index so that intended HARQ-ACK codebook is chosen). Mediatek [20] (…slot index(-ices) pointing back in time selecting the codebook(s) that are requested for resending), DoCoMo [26] (all HARQ-Ack within a time window, where the scheduling DCI indicates the time window (slot offset, number of slots)), WILUS [28]
* **Last dropped HARQ-ACK codebook** (**2**): Ericsson [4], ZTE [6] (i.e. Solution 1)
* **Concatenation of dropped HARQ-ACK codebooks in order** (2xYes – 1x No): ZTE [6], Mediatek [20] – No: Only a single cancelled HARQ-ACK CB is re-transmitted: Qualcomm [16]
* gNB to request “*UE Indication of Cancelled HARQ CB*” from UE and therefore, gNB will be made aware if and which CB has been canceled (**1**): Qualcomm [16]
* PHY priority indication in the triggering indicates the PHY priority of the HARQ-ACK codebook to be re-transmitted (3): Mediatek [20], Nokia/NSB [3], DoCoMo [26]

**Triggering indication in the DCI:**

* **Explicit triggering indication in the DCI (3):** ZTE [6], Sony [7] (for DCI format 1\_1 using *One-shot HARQ-ACK request*, FFS for 1\_2), Mediatek [20]
  + Can be triggered as early as possible after the conflict is determined: ZTE [6]
* **Implicit triggering by multiplexing on the next scheduled PUCCH resource indicated by a DCI for HARQ-ACK transmission (2):** Ericsson [4], Mediatek [20]
* **Implicit triggering by a DCI scheduling a re-transmission (1):** OPPO [14]
  + A LP PUCCH, including the HARQ-ACK for HARQ process X, is cancelled by a HP PUCCH. UE receives a DCI indicating HARQ process X without NDI toggle, then LP PUCCH should be retransmitted based on the PRI and k1 indicated by the DCI.
* **Implicit triggering using a different RNTI (1):** Mediatek [20]
* **Implicit triggering of HARQ-ACK re-transmission based on indication of two HARQ-ACK transmission occasions in DCI (1):** Lenovo/Motorola [13]
  + The DCI scheduling the initial PUCCH transmission also provides information on the HARQ-ACK re-transmission and UE uses this information for re-transmission if the initial transmission is canceled.

**Multiplexing of re-tx HARQ-ACK and new HARQ-ACK:**

* For Type 1 CB:
  + only the Type 1 CB to be retransmitted is mapped (UE does not expect any new / initial HARQ-ACK in the same slot): Nokia/NSB [3]
  + retransmitted HARQ-ACK bits appended to the initial HARQ-ACK codebook: CATT [9]
* For Type 2 CB, the Type 2 CB to be retransmitted is appended to the ‘new, initial’ Type 2 CB: Nokia/NSB [3], CATT [9]

**Other:**

* Consider first LP HARQ: ZTE [6] – No: Focus on HP HARQ: Mediatek [20]
* Triggering DCI to indicate the DAI of the Type 2 CB to be re-transmitted: Sony [7]
* In addition to trigger the re-tx of a HARQ-ACK CB, also the triggering of re-transmission of a PUCCH (incl. other UCI) should be considered: LGE [18]
* Support at least non-scheduling DCI triggering one-shot HARQ-ACK transmission: Interdigital [22]

**Other than enh. Type 3 & One-shot Triggering:**

**Enhanced Type 2 CB:** Clarification that PDSCH grouping for Enh-Type2 CB is within each PHY priority:vivo [2] (then readily available)

**Joint operation of one-shot triggering and e-Type 3 CB - UE selects one of these CBs depending on the number of dropped HARQ-ACK:** Sony [7]

* **If the number of dropped HARQ-ACK ≤ *THARQ*, the UE selects Dyn-ReTx CB**
* **If the number of dropped HARQ-ACK > *THARQ*, the UE selects e-Type 3 CB**

**Autonomous one-shot HARQ-ACK re-transmission for all or a subset of HARQ processes in an earlier CG-PUSCH resource:** Lenovo/Motorola [13]

**Automatic re-tx of canceled HARQ-ACK (if multiplexed on PUSCH) on the PUSCH re-transmission with the same resource allocation:** Qualcomm [16]

* Limited to UL-CI operation (i.e. dropping due to DCI format 2\_4 reception)
* If a PUSCH incl. HARQ is canceled, the cancelled HARQ-ACK is multiplexed on the PUSCH re-transmission automatically with the same resource allocation including same NDI, TBS, MCS, HARQ Process ID
* Only HARQ-ACK is to be re-transmitted (drop CSI)
* No multiplexing of new UCI on the PUSCH re-tx
* No support for partial automatic (re)transmission of cancelled HARQ bits

**Automatic (re)transmission of a single dropped LP HARQ-ACK CB. Automatic (re)transmission at the same PRI as the one for the initial PUCCH allocation; PRI allocation valid for up to N slots**: Qualcomm [16]

* Study joint configuration of automatic re-transmission, ‘One-short triggering’ and PUCCH carrier switching
* Proposed related procedure:

*Execution of* *“automatic (re)transmission of dropped or cancelled HARQ-ACK” starts immediately after HARQ-ACK dropping or cancellation and it stops:*

1. *when appropriate PUCCH resource for the transmission of the single dropped LP HARQ-ACK is found, or*
2. *upon reception of PUSCH allocation (DCI 0\_x) with same NDI and HARQ ID(s) as the allocation of the initially cancelled PUSCH via DCI 2\_4 , or*
3. *when a request for “1-shot HARQ (re)transmisison” is received, or*
4. *when a “PUCCH-Carrier Switch Command” is received in DCI (in case of more than 1 PUCCH CCs)*
5. *when the validity of the PUCCH Resource for the single dropped LP HARQ CB expires.*
   1. 1st Round of email discussions

***Moderator comments:***

4 companies suggest confirming the RAN1#105-e working assumption and not a single company raised any reservations. Therefore, the following is proposed:

**Proposal 3.1: Confirm the following RAN1#105-e working assumption:**

Working Assumption: For at least HARQ-ACK re-transmission:

* Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16) in Rel-17
  + *Definition of enhanced Type 3 CB:* 
    - *The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration*
    - *The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)*
* Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17
  + *Details are FFS*
* Enhanced Type 3 HARQ-ACK CB and/or one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB are subject to separate UE capabilities

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, Sony, Sharp, ZTE, DOCOMO, Samsung Spreadtrum, TCL Qualcomm, NEC, CATT, China Telecom, Mediatek |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Intel | It is not urgent to confirm the WA |
| Moderator | @Intel: would prefer to confirm the WA, not to spent endless time on the design discussions and decisions and then last minute to drop the feature. Do you have any concern to confirm the working assumption?? |
|  |  |
|  |  |
|  |  |

**Type 3 CB related:**

**10 companies** indicated to support dynamic indication in the triggering DCI of the enh. Type 3 CB of smaller size to be transmitted, **whereas 3 companies** indicate that the enh. Type 3 HARQ-ACK codebook of smaller size should only be defined by RRC configuration and/or activation. Therefore, the following is proposed:

**Proposal 3.2: Support dynamic selection based on indication in the triggering DCI of one of multiple (configured) enh. Type 3 HARQ-ACK CB(s) of smaller size.**

* **Details are FFS**

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Intel, Sharp, DOCOMO, Samsung, Spreadtrum, ETRI, NEC, LG |
| Objecting companies | Ericsson, Sony, Qualcomm, CATT, Huawei |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | As discussed in our contribution, we think such dynamic indication is preferred as based on the dropped HARQ or not correctly received HARQ information, the gNB has the choice from one of more CBs to trigger. |
| Panasonic | Although our preference is only be defined by RRC configuration and/or activation, we can live with the proposal. We think the configured multiple Type-3 HARQ-ACK codebook(s) should have the size only dependent on RRC configuration and/or activation. |
| Ericsson | Type-3 CB is about reporting all HARQ-ACK bits of all HARQ processes. The intention of enhanced Type-3 is to make the CB size smaller. There is no need to further have dynamic indication indicating specific subset/configuration as it would overlap with the other solution based on one-shot triggering DCI.  If seems to us, the supporting companies also support to confirm WA. For us, there should be a clear delta between these two approaches. The spirit of Type-3 should remain. Any dynamic optimization should be done by the second solution. |
| Sony | The rationale behind multiple e-Type 3 CB configuration is for optimising the size of the CB. For optimised CB size, we can use the new dynamic CB since it retransmits only dropped HARQ-ACK. Otherwise if size isn’t the issue, then use ONE configured e-Type 3 CB.  If we want a dynamic selection, a simple selection can be selection between ***ONE*** configured e-Type 3 CB and the new dynamic CB based on the number of HARQ-ACK retransmission. |
| Intel | At least minimal configurability is essential for the feature to be useful, thus we support DCI-based configuration of CBs. |
| Samsung | Agree in principle with E/// but the two “solutions” will be separate UE capabilities.  A NW should be able to get the HARQ-ACK info it wants without (much) rescheduling regardless of which of the two solutions a UE implements. |
| Qualcomm | In addition to the arguments from Panasonic, Ericsson, Sony, the proposal increases DCI overhead. |
| CATT | We share the view from Ericsson, Sony and Qualcomm. This proposal would require significant specification efforts on DCI design. |
| LG | Considering type-3 codebook trigger, there could be a way to facilitate dynamic indication without DCI overhead. |
| Huawei | As we mentioned in the previous meetings, the condition we would accept the WA is to make the Type 3 CB enhancement as simple as possible. There is no strong need to over-optimize the HARQ retransmission and introduce large overhead in DCI. |

Companies had been proposing different enh. Type 3 CBs. Clearly, more than one CB could be supported (even if only based on RRC configuration and/or activation is supported), as a different codebook could be configured at certain times for a UE. So let’s try to get some input where companies stand here. **Please add your companies name directly to the Alternatives in the question and provide your additional comments or alternatives in the table below.**

**Question 3.1: Which of the following enhanced Type 3 CBs of smaller size do you support:**

* **Alt. 1: HARQ processes of a subset of configured CCs**
  + **Supporting companies: Nokia/NSB, OPPO, vivo, Panasonic, Sony, Intel, Sharp, DOCOMO, ETRI,NEC, LG, Huawei, Lenovo/Motorola Mobility** …
  + **Companies not supporting:** …
* **Alt. 2: Subset of configured HARQ processes (specific to CCs)**
  + **Supporting companies: Nokia/NSB, vivo, Panasonic, Intel, DOCOMO, ETRI, NEC, CATT, LG, Huawei, Lenovo/Motorola Mobility**…
  + **Companies not supporting:** …
* **Alt. 3: HARQ processes of only activated CCs** 
  + **Supporting companies: Panasonic, Intel, ETRI, NEC, CATT, LG, Ericsson** …
  + **Companies not supporting:** …
* **Alt. 4: SPS HARQ processes only (based on configured SPS processes)**
  + **Supporting companies: Intel, ETRI, NEC, LG,**…
  + **Companies not supporting:** …
* **Alt. 5: SPS HARQ processes only (based on activated SPS processes)**
  + **Supporting companies: Intel, ETRI, NEC, LG,** …
  + **Companies not supporting:** …
* **Alt. 6: HARQ processes of specific SPS configurations of configured CCs** 
  + **Supporting companies: NEC** …
  + **Companies not supporting:** …
* **Alt. 7: HARQ-IDs / processes within time window starting t0 prior to the triggering DCI** (for details, check 16])
  + **Supporting companies:** …
  + **Companies not supporting: Nokia/NSB, Panasonic, Intel** …
* **Alt. 8: Dropped HARQ-ACK processes only** 
  + **Supporting companies:** …
  + **Companies not supporting: Nokia/NSB, Panasonic, Intel, DOCOMO,** …
* **Alt. 9: Other**
  + **Supporting companies:** …

|  |  |
| --- | --- |
| *Company* | *Comments or Alt. 9 – other options* |
| Nokia, NSB | We support Alt. 1, Alt. 2 as they all have the size only dependent on configuration (and not any activation etc., which could lead to CB size ambiguities).  The biggest issues with CB size ambiguity we see with Alt. 7 and Alt. 8 (which we actively oppose) but similar issues are there for Alt. 3 and Alt. 5. Alt. 4 & Alt. 6 can be by gNB implementation also achieved with Alt. 2, by configuring the related HARQ processes there (so no need to define this specifically). |
| OPPO | Alt 1 for simplicity and size reduction of Type 3 CB is significant. |
| Sony | **Alt 1** is the only sensible option.  Alt 2 and Alt 3 require the gNB to have a crystal ball to know which HARQ Process ID would be dropped in the future  Alt 4, Alt 5 and Alt 6 is NOT a Type 3 based CB. We already agreed that Type 3 CB arranged according to a set of fixed HARQ Process ID. The SPS HARQ Process IDs are dynamically determined (depending on which slot it is transmitted, periodicity, number of HARQ processes, etc). How is it possible for a Type 3 CB to retransmit only SPS HARQ-ACKs?  Alt 7 and Alt 8 is NOT a Type 3 based CB. It is effectively a dynamic CB with a dynamic size. Hence it isn’t clear why it is even an option under e-Type 3 CB. |
| Intel | We like many options, which could be realized by proper design of how Type 3 CB is configured and triggered.  Alt.7 and Alt.8 the issue of uncertain CB size due to missed DCIs. |
| Sharp | We prefer Alt. 1. |
| Samsung | Alt. 1.  We understand Alt. 1 to be that a UE is configured some states and a field in the DCI indicates one of the states, and that a state is a configured {subset a cell, subset of HARQs}.  Same view with Nokia for the other alternatives. |
| Qualcomm | Suggestion: defer the discussion on the Type 3 CB Content for after agreements on the HARQ Type 3 CB Size and on the triggering method.  The options/suggestions are all sensible but they will open up many discussions which will deviate from the goal of the group now: define the Enhanced Type 3 CB size and how it will be configured.  Support for Alt 1-3 as mentioned by supporting companies. E.g. for Alt 2, the UE places only SPS HARQ for SPS configurations for which SPS HARQ deferral is NOT activated.  Support for Alt 4-6 for the case the Enhanced Type 3 CB is used for SPS PUCCH collisions with DL.  Support for Alt 7 due to its approach to delineate the HARQ CB content.  Support for Alt 8 as well. For this solution to work though, there is a need to have a common understanding at both UE and gNB of what is dropped. Therefore there is a need for a UE indication of “cancelled CB”, see Proposal 18.  ***Proposal 18: For the “one-shot triggering of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (second option of the working assumption):***   * ***support the transmission of only a single “cancelled HARQ-ACK CB” within a given time window*** * ***support gNB request for “UE Indication of Cancelled HARQ CB” in DCI 1\_1 or DCI 1\_2 with an extra bit.***   ***support the indication of the UE of “cancelled HARQ” in UCI, only upon gNB request; “UE indication of cancelled HARQ” bit set to 1 upon existence of at least 1 “cancelled HARQ CB”.*** |
| NEC | We support Alt.1~Alt.6. In our views, all these alternatives can reduce the codebook size. While Alt.7 and Alt.8 should be achieved by one-shot HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB. |
| CATT | We support Alt. 2 and 3. We think Alt. 1 can be achieved by Alt. 2. |
| LG | We support Alt. 1 - 5. |
| Huawei | Alt .1/2. |
| Lenovo, Motorola Mobility | Alt 1 and Alt 2 |
| Ericsson | Alt 3 (is the easiest one to start with).   * We are a bit puzzled by Nokia’s comments. Isn’t the Alt 3 about considering activated cells than configured?   On Alt 1 /Alt 2, it is not clear how to interpret. Is is correct understanding the following:   * Alt 1 means to us means basically for a subset of configured CC. * Alt 2 means for a subset of HP to CC   So, it means if one applies Alt1/Alt 2, then applying Alt 3 would change the limitation by considering the applicable configured CCs that are activated.  It is correct? A bit confusing 😊 |

**Looking at the PHY priority handling, the following can be noted:**

* **13 companies** indicated the need to **support PHY priority handling** for enh. Type 3 HARQ-ACK codebooks of smaller size
* **8 companies** indicated, that the **HARQ-ACK information** of HARQ processes **should be mapped** to the enh. Type 3 HARQ-ACK codebooks of smaller size **irrespective of the PHY priority of the ‘HARQ-ACK’**– **whereas 1 company** indicated that **only HARQ-ACK information** which was associated with the **indicated priority** should be mapped
* **~4 companies** propose, that the **enh. Type 3 HARQ-ACK CB of smaller size** could have a **different structure or size depending on the priority**

Based on this, the following is proposed for Rel-16 Type 3 HARQ-ACK codebook and the Rel-17 enh. Type 3 HARQ-ACK CB of smaller size:

**Proposal 3.3:** **Support PHY priority handling for a PUCCH carrying the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size.**

* **The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size.**
* **The A/N of HARQ processes is mapped to the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size irrespective of the PHY priority of the ‘A/N’ of the HARQ processes.**
* ***FFS:* *If the HARQ-ACK codebook size or structure is dependent on the PHY priority (e.g. separate configuration of CBG/NDI usage, separate configuration of HARQ IDs / CCs per priority, SPS HARQ-ACK process IDs of specific priority only for a SPS HARQ-ACK only codebook, …).***

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Sony, Intel, Sharp, DOCOMO, Samsung, QC, ETRI, NEC, CATT, China Telecom, FGI/APT, LG, Huawei, Ericsson, Mediatek |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| ZTE | We are not fine for the second sub-bullet. The construction of the enhanced type 3 codebook could be based on the priority indication, which means the HARQ process with different priorities will be separated to construct the enhanced type-3 codebook.  Moderator comment: Just to check here, if I have a codebook that contains certain HARQ-IDs, the payload size transmitted is not changed if HARQ-ACK information is not mapped irrespective of priority – right? So what you are proposing is that, we still have the payload size but don’t on purpose use the ability to gather HARQ information from the UE. Any reason for doing so – any advantages there (… payload size is the same, so why not map the HARQ bits when available)??  The same applies even if we have a enh. Type 3 CB structure / size for LP and a separate Type 3 CB structure / size (based on the FFS) |
| QC | This feature will increase the standardization effort though. Rel. 17 can be specified without it. |
| Ericsson | Support |
|  |  |
|  |  |

**Proposal 3.4:** **Support PHY priority handling for a PUCCH carrying the Rel-16 Type 3 HARQ-ACK CB in Rel-17.**

* **The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-16 Type 3 HARQ-ACK CB.**
* **The A/N of HARQ processes is mapped to the Rel-16 Type 3 HARQ-ACK CB irrespective of the PHY priority of the ‘A/N’ of the HARQ processes.**
* **The support is subject to a Rel-17 UE capability and a UE supporting this capability can be configured in Rel-17 with Rel-16 Type 3 HARQ-ACK CB and PHY prioritization.**

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Sony, Intel, Sharp, DOCOMO, Samsung, Qualcomm, ETRI, NEC, CATT, China Telecom, FGI/APT, LG, Huawei, Ericsson |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| QC | This feature will increase the standardization effort though, even if the feature is useful. Can this discussion be taken in the Rel. 16 eURLLC group?  Moderator reply: This requires UE capability and RRC signaling 🡪 R16 is frozen |
| Ericsson | Support |
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There had been proposals for the PHY priority handling for the enh. Type 3 CB to support different configurability for the enh. Type 3 CB structure / content. Let’s check companies views on this:

**Question 3.2: For the PHY priority handling of the enhanced Type 3 CB(s) of smaller size, which Alt. do you support:**

* **Alt. 1: the enhanced Type 3 HARQ-ACK has the same structure, size and content (in terms of HARQ-IDs, CCs) irrespective of the PHY priority**
  + **Supporting companies: Nokia/NSB, OPPO, vivo, Panasonic, Sony, Intel, Sharp, Samsung, DOCOMO, ETRI, NEC, CATT, China Telecom, FGI/APT, LG, Huawei, Ericsson**…
* **Alt. 2: PHY priority specific configuration of CBG and NDI usage** 
  + **Supporting companies: Nokia/NSB, vivo, China Telecom, FGI/APT**…
* **Alt. 3: PHY priority specific configuration of subset of configured HARQ processes (specific to CCs)**
  + **Supporting companies:** …
* **Alt. 4: For SPS HARQ process only CB, only the SPS HARQ-ACK process IDs of a specific priority are included** 
  + **Supporting companies:** …
* **Alt. 5: Other**
  + **Supporting companies:** …

|  |  |
| --- | --- |
| *Company* | *Comments or Alt. 5 – other options* |
| Nokia/NSB | Alt. 1 or Alt. 2 (removal of e.g. CBG for HP HARQ could be useful). Alt. 3 and Alt. 4 may be considered as unnecessary optimizations. |
| OPPO | Alt.1 |
| vivo | At least Alt.1 and Alt.2.  If time allows, further optimization like Alt.3 can be considered. |
| Sony | Alt.1. It is unclear how Alt. 3 and Alt.4 would work as it fix the L1 priorities to HARQ process IDs. |
| Sharp | Alt.1 |
| Samsung | Alt.1 only.  The other Alts will only complicate specifications without offering any meaningful benefit (the benefit is the functionality itself). Also, the other Alts become more unnecessary if the triggering can point to cells/HARQ processes as selected by the gNB (as discussed in previous proposals). |
| Qualcomm | No solid preference now. Alt 1 is the simplest and the group can start with it. There are benefits in all alternatives but some supporting mechanisms need to be standardized. |
| FGI/APT | Alt. 1 and Alt. 2. |
| LG | Support Alt. 1 |
| Huawei | Alt.1 only for simple. |
| Ericsson | Alt 1 |

**DCI format 1\_2 utilization**

**8 companies propose the usage of DCI format 1\_2 for the triggering (with nobody actively opposing).** Therefore, the following is proposed for Rel-16 Type 3 HARQ-ACK codebook and the Rel-17 enh. Type 3 HARQ-ACK CB of smaller size:

**Proposal 3.5:** **Support Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size triggering using DCI format 1\_2 for a UE supporting DCI format 1\_2.**

* **The triggering support for DCI format 1\_2 is independently (from triggering using DCI format 1\_1) RRC configured to the UE.**

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Sony, Intel, DOCOMO, Samsung, Qualcomm, ETRI, NEC, CATT, China Telecom, FGI/APT, Huawei, Ericsson |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
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**Proposal 3.6:** **Support Rel-16 Type 3 HARQ-ACK CB triggering using DCI format 1\_2 in Rel-17 for a UE supporting DCI format 1\_2.**

* **The support is subject to a Rel-17 UE capability and a UE supporting this capability can be configured with DCI format 1\_2 triggering of the Rel-16 Type 3 HARQ-ACK CB.**

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Sony, Intel, DOCOMO, Samsung, Qualcomm, ETRI, NEC, CATT, China Telecom, FGI/APT, Huawei |
| Objecting companies |  |

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| *Company* | *Comments* |
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**Handling of ‘new’ HARQ-ACK information which cannot be mapped to the enhanced Type 3 HARQ-ACK codebook of smaller size:**

With the smaller Type 3 codebook size not all HARQ processes of all CCs are present in the codebook, and the question arises, what to do if in the PUCCH slot where the enh. Type 3 CB of smaller size is to be transmitted there is also ‘new, initial’ HARQ-ACK information scheduled that cannot be mapped to the enh. Type 3 CB. The following two options were discussed in TDocs by different companies:

* Alt. 1: Any ‘new, initial’ HARQ-ACK information for transmission in the same PUCCH slot that cannot be mapped to the enhanced Type 3 CB of smaller size is not transmitted/ dropped: Nokia/NSB [3], Intel [21]
* Alt. 2: UE is not expecting ‘new, initial’ HARQ-ACK information for transmission in the same PUCCH slot that cannot be mapped to the triggered enhanced Type CB of smaller size: Intel [21]

**Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below:**

**Question 3.3: How to handle multiplexing of ‘new, initial’ HARQ-ACK information scheduled for transmission in the same PUCCH slot that cannot be mapped to the enhanced Type 3 HARQ-ACK codebook of smaller size as the HARQ process is not part of the codebook:**

* **Alt. 1: ‘New, initial’ HARQ-ACK information which cannot be mapped is dropped / not transmitted**
  + **Supporting companies: Nokia/NSB, OPPO (only single Type 3 CB), Panasonic, DOCOMO, ETRI, NEC(?)** …
* **Alt. 2: UE is not expecting ‘new, initial HARQ-ACK information’ which cannot be mapped.** 
  + **Supporting companies: vivo, Sony, Samsung, Qualcomm, CATT, NEC(?), LG, Huawei, Lenovo/Motorola Mobility, Ericsson** …
* **Alt. 3: Other**
  + **Supporting companies:** …

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| *Company* | *Comments or Alt. 3 – other handling* |
| Nokia/NSB | Alt. 1 for simplicity. Alt. 2 may create limitations for Gnb in requesting the Type 3 CB with SPS HARQ-ACK operation 🡪 not preferred |
| OPPO | If ‘new, initial’ HARQ-ACK information is carried in Type 1 or Type 2 HARQ-ACK codebook, we prefer to follow existing rule, i.e. Alt.1  If ‘new, initial’ HARQ-ACK information is carried in enhanced Type3 HARQ-ACK codebook, in other words, more than one enhanced Type 3 HARQ-ACK codebook trigged in the same slot can be multiplexed in one PUCCH. For example, enhanced Type 3 HARQ-ACK codebook 1 indicating HARQ-ACK for carrier 1-2 and enhanced Type 3 HARQ-ACK codebook 2 indicating HARQ-ACK for carrier 3-4 are trigged in the same slot, then HARQ-ACK for carrier 1-4 should be multiplexed in one PUCCH.  Above proposal is applicable for the case that other HARQ-ACK codebook and enhanced Type 3 HARQ-ACK occurs simultaneously. So we suggest to modify:  **Question 3.3: How to handle multiplexing of ~~‘new, initial’~~ HARQ-ACK information ~~scheduled for transmission~~ in Type 1 and Type2 HARQ-ACK codebook in the same PUCCH slot that cannot be mapped to the enhanced Type 3 HARQ-ACK codebook of smaller size as the HARQ process is not part of the codebook:**  Note: Legacy Type 3 HARQ-ACK codebook and enhanced Type 3 HARQ-ACK codebook is not expected to be configured simultaneously and legacy Type 3 HARQ-ACK codebook can be implemented as a special case of enhanced Type 3 HARQ-ACK codebook. |
| Vivo | We support Alt.2 and Alt.2 is also simple.  We have Rel-16 Type 3 CB and Rel-17 enhanced Type 3 CB, it is not difficult for Gnb to ensure that ‘new, initial HARQ-ACK information’ can be mapped to the enh. Type 3 CB. |
| Panasonic | We share the similar view with Nokia. Alt.1 is preferred. |
| Sony | Alt.2. This is a strange behaviour to schedule the HARQ-ACK to a PUCCH that doesn’t allow that HARQ-ACK to be transmitted. |
| Intel | Either Alt.1 or Alt.2 |
| DOCOMO | Alt 1 is simple. |
| Samsung | Alt.2 is simplest and sufficient – no need to complicate UE behaviour. There is no Gnb impact.  There are 3 possibilities, none of them necessitates Alt.1:   1. Worst case is that R16 may occasionally apply when a Gnb happens to (a) want to continuously schedule a UE in consecutive DL slots, and (b) want to trigger Type-3, and (c) cannot choose a HARQ process for the TB that is in the set of triggered ones. 2. Gnb can indicate subset of HARQ processes it wants and there is no issue (discussed in previous proposals). 3. There is no PDSCH scheduling in the slot where Type-3 is triggered.   Also, Alt.2 will anyway need to be supported since a mandatory UE capability is for only one DL DCI per slot (regardless of whether or not it schedules PDSCH). |
| QC | Alt 2. |
| NEC | Alt.2. |
| LG | Support Alt. 2 |
| Huawei | Alt.2 |
| Lenovo/Motorola Mobility | Alt 2. gNB can guarantee transmission of ‘new, initial’ HARQ-ACK information by triggering legacy type 3 CB transmission. |
| Ericsson | Alt 2  Any other solution, defeats the properties of Type 3 and how t can be used. When Type 3 is used, NW is after a almost full report from UE. If NW wants more specific reports, the Type 3 is not the proper tool. Also it seems Alt 1 is effectively Alt 2. |

**One-shot triggering related proposals:**

**10 companies** propose a dynamic indication in the triggering DCI to define the HARQ-ACK codebook(s) to be re-transmitted **whereas 2 companies think such indication is not needed** (.. and just the last dropped HARQ-ACK codebooks is to be re-transmitted)**.**

Looking at this strong majority preferring some dynamic indication the following is proposed:

**Proposal 3.7:** **The DCI triggering (by a DL assignment) the one-shot HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB** **dynamically indicates the HARQ-ACK codebook(s) / PUCCH occasions to be re-transmitted.**

* ***FFS details***

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Sony, ZTE, DOCOMO, Samsung, Qualcomm, NEC, CATT, China Telecom, FGI/APT, LG, Lenovo/Motorola Mobility |
| Objecting companies |  |

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| *Company* | *Comments* |
| Nokia/NSB | As laid out it our contribution, e.g. the HARQ-ID field could be used to indicated the PUCCH slot offset between the initial PUCCH slot and the re-transmission PUCCH slot (limited to indicate a single slot) |
| ZTE | For the DCI triggering, one example is shown which could support multiple retransmissions of cancelled HARQ-ACK codebooks.   * + *Support a new DCI format for scheduling one or more cancelled HARQ-ACK codebooks.* * *The fields of size of one or more HARQ-ACK codebooks are included in the DCI.* * *The order of the multiple size fields of one or more HARQ-ACK codebooks in the DCI is determined based on the order of the PUCCHs starting symbols corresponding to the cancelled HARQ-ACK codebooks.* |
| DOCOMO | We want to use a DCI not scheduling PDSCH for such triggering. And some fields (e.g. TDRA) can be used to indicate a time window for multiple HARQ-ACK slots. |
| QC | Dynamic indication can be in the form of “last cancelled” HARQ CB. The term “**re-transmitted**” is not suitable, since the discussion is about either dropped or cancelled HARQ CB, that are never transmitted in the past and they are now transmitted for the 1st time. Therefore, there is support for:  **The DCI triggering (by a DL assignment) the one-shot HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB** **dynamically indicates the cancelled/dropped/deferred HARQ-ACK codebook(s) / PUCCH occasions to be ~~re-~~transmitted.**   * ***FFS details*** |
| Huawei | We need to consider the ambiguity case where the UE misses the DCI and performs DTX at a specific PUCCH occasion, while the gNB indicates the UE to retransmit the HARQ-ACK on that specific PUCCH occasion. The indication such as DAI is needed to allow the UE to confirm the exact HARQ-ACK payload to be retransmitted. |
| QC | Agreement that the network should indicate dynamically or semi-statically the requested HARQ CB. However, this indication can be achieved by other than “PUCCH ID or counter” or “HARQ CB ID or Counter” methods.  Second Huawei’s comment. For the proposal to work there is a need for 2 new fields in the DCI 1\_1 or 1\_2 requesting the “cancelled HARQ”:   1. PUCCH Id/Counter (or HARQ CB Id/Counter) 2. HARQ CB size   If the counter is measured in 2 bits, and the HARQ CB size can be up to 8 bits, then ,there is a need for 5 extra bits (2 bits for the PUCCH counter and 3 for the HARQ CB) in the DCI for getting back a single cancelled HARQ bit. In addition, the solution with the PUCCH counter starts to be very similar to Enhanced Type 2 HARQ. |

Looking at the input give, some companies think a single triggering DCI should only trigger the re-transmission of a single PUCCH occasion / HARQ-ACK CB whereas some companies think, a single triggering DCI could trigger the re-transmission of HARQ-ACK information of more than one PUCCH occasion. **Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below:**

**Question 3.4: A single DCI triggering the Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB can trigger the re-transmission of HARQ-ACK information of:**

* **Alt. 1: only a single HARQ-ACK CB**
  + **Supporting companies: Nokia/NSB, OPPO, vivo, Panasonic, Sony, Sharp, Samsung, Qualcomm, ETRI, CATT, China Telecom, FGI/APT,** …
* **Alt. 2: one or more HARQ-ACK CBs. The multiple HARQ-ACK CBs to be re-transmitted are concatenated.** 
  + **Supporting companies: ZTE, DOCOMO, Lenovo/Motorola Mobility** …
* **Alt. 3: Other**
  + **Supporting companies:** …

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| *Company* | *Comments or Alt. 3 – other handling* |
| Nokia/NSB | Alt. 1: A single HARQ-ACK CB for simplicity. |
| OPPO | Alt.1 |
| vivo | We support Alt.1. |
| Panasonic | We prefer Alt.1 for simplicity. |
| Sony | Alt.1. The gNB can trigger a retransmission for HARQ-ACK CB for each dropped PUCCH. |
| Sharp | We prefer Alt. 1. |
| ZTE | Alt.2. Multiple HARQ-ACK CBs could be supported to be retransmitted. |
| DOCOMO | Al 2.  It would be more efficient if re-transmission of multiple HARQ-ACKs can be achieved by one DCI instead of multiple DCIs. One HARQ-ACK CB for re-transmission can be regarded as a special case. |
| Samsung | Alt.1 is probably sufficient but may conclude this at a later time after deciding on scheduling/non-scheduling DCI or on available bits for indication. It may also relate to similar decisions made for HARQ-ACK skipping. Nevertheless, if things need to be progressed now, OK with Alt. 1. |
| Qualcomm | Alt 1 since in a good planned system, there should not be more than 1 “cancelled” HARQ CBs in a short period of time. |
| FGI/APT | Alt. 1 for simplicity. |
| LG | Support Alt. 1 . |
| Huawei | This question depends on how to indicate the dropped HARQ-ACKs. E.g., if the PUCCH occasion is indicated, all HARQ-ACKs on the PUCCH can be re-transmitted; if the specific HARQ ID(s) are indicated, only one CB is retransmitted. |
| Lenovo/Motorola Mobility | Alt 2, which can reduce a triggering DCI overhead. |

There had been different proposals on how to trigger indication ‘by a DL assignment’ is done. To see where companies stand, **please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below**

**Question 3.5: The Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB is done through:**

* **Alt. 1: Explicit triggering indication in the DCI through a DCI field (as for enh. Type 2 and Type 3 CB)**
  + **Supporting companies: Nokia/NSB, OPPO, vivo, Panasonic, Sony, ZTE, Samsung, DOCOMO, QC, ETRI, NEC, CATT, FGI/APT, LG, Huawei, Lenovo/Motorola Mobility, Ericsson,** …
* **Alt. 2: Implicit triggering by multiplexing on the next scheduled PUCCH resource indicated by a DCI for HARQ-ACK transmission** 
  + **Supporting companies:** …
* **Alt. 3: Implicit triggering by a DCI scheduling a re-transmission** (for details see the summary above & OPPO contribution in [14])
  + **Supporting companies: OPPO**…
* **Alt. 4: Implicit triggering using a different RNTI**
  + **Supporting companies: ETRI,** …
* **Alt. 5: Other**
  + **Supporting companies: Lenovo/Motorola Mobility** …

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| *Company* | *Comments or Alt. 5 – other handling* |
| Nokia, NSB | Alt. 1, following the enh. Type 2 and Type 3 CB triggering (for simplicity) |
| OPPO | Alt.1 and Alt.3. Alt 3 avoids additional information bit in DCI. |
| Vivo | Alt.1. For simplicity and also avoid miss-understanding. |
| Sony | Alt.1. The name of this feature is called “one-shot” triggering CB, and hence we would expect this “one-shot” filed in the DCI is used to trigger the CB |
| ZTE | Alt.1 |
| Samsung | It may depend on whether only one CB or multiple CBs can be indicated. If one CB, Alt. 1 is fine. If multiple CBs, a non-scheduling DCI should also be considered (same framework as for indicating Scell dormancy in R16 by either a scheduling or a non-scheduling DCI).  To not prolong the discussion, fine with Alt. 1. |
| QC | Alt 1 |
| ETRI | Alt 1 and Alt 4.  Alt 4 may be applied for some cases where SPS HARQ-ACK is retransmitted. |
| NEC | Alt.1. |
| FGI/APT | Alt.1 |
| LG | Alt. 1 |
| Huawei | Alt.1. |
| Lenovo, Motorola Mobility | Alt 1 and Alt 5. Implicit triggering of HARQ-ACK retransmission can reduce a triggering DCI overhead. For example, a codepoint of a PDSCH-to-HARQ-timing-indicator field in DCI can indicate multiple values for the number of slots (or sub-slots). If a UE cannot perform HARQ-ACK transmission on an earlier HARQ-ACK transmission occasion, the UE can perform retransmission of cancelled HARQ-ACK transmission on a later HARQ-ACK transmission occasion, without receiving a separate triggering DCI format. |
| Ericsson | Alt 1 |

**PHY priority handling**

Although only suggested by 3 companies (but nobody actively against based on the TDocs), there is also for this feature the need for PHY priority indication to (a) define the PHY priority carrying the re-transmitted HARQ-ACK information and (b) define which HARQ-ACK codebook (LP or HP) is to be re-transmitted. Therefore, the following is proposed to be agreed:

**Proposal 3.8:** **Support PHY priority handling for the Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB.**

* **The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the re-transmitted HARQ-ACK information.**
* **The indicated PHY priority in the triggering DCI is used to determine the HARQ-ACK information to be re-transmitted corresponding to the indicated PHY priority.**

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

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| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, Panasonic, Sony, ZTE, DOCOMO, Samsung, QC, ETRI, NEC, CATT, FGI/APT, Huawei, Ericsson |
| Objecting companies |  |

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| *Company* | *Comments* |
| vivo | We would be fine with the proposal. One clarification: the indicated PHY priority field for above (a) define the PHY priority carrying the re-transmitted HARQ-ACK information and (b) define which HARQ-ACK codebook (LP or HP) is to be re-transmitted is the same field or different fields?  Moderator: Using the existing PHY priority field, at least this was moderators understanding. |
| Samsung | Other approaches also exist (e.g. allow HP/LP DCI to indicate either LP or HP retransmission) but the proposal is both sufficient and simplest. |
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* 1. 1st checkpoint proposals (Aug. 19th)

Based on the first round, all companies seemed to be fine with confirming the working assumption from RAN1#105-e. Therefore, the following proposal is directly copied from the 1st round including the supporting companies:

**Proposal CP3.1: Confirm the following RAN1#105-e working assumption:**

Working Assumption: For at least HARQ-ACK re-transmission:

* Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16) in Rel-17
  + *Definition of enhanced Type 3 CB:* 
    - *The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration*
    - *The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)*
* Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17
  + *Details are FFS*
* Enhanced Type 3 HARQ-ACK CB and/or one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB are subject to separate UE capabilities

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, Sony, Sharp, ZTE, DOCOMO, Samsung Spreadtrum, TCL Qualcomm, NEC, CATT, China Telecom, LG… |
| Objecting companies |  |

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| *Company* | *Comments* |
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**Type 3 CB related:**

The PHY priority handling for Rel-16 and Rel-17 of proposals 3.3 and 3.4 received only support, so this is suggested to go for checkpoint handling.

**Proposal CP3.2:** **Support PHY priority handling for a PUCCH carrying the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size.**

* **The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size.**
* **The A/N of HARQ processes is mapped to the Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size irrespective of the PHY priority of the ‘A/N’ of the HARQ processes.**
* ***FFS:* *If the HARQ-ACK codebook size or structure is dependent on the PHY priority (e.g. separate configuration of CBG/NDI usage, separate configuration of HARQ IDs / CCs per priority, SPS HARQ-ACK process IDs of specific priority only for a SPS HARQ-ACK only codebook, …).***

Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Sony, Intel, Sharp, DOCOMO, Samsung, QC, ETRI, NEC, CATT, China Telecom, FGI/APT, LG, Huawei, Ericsson |
| Objecting companies |  |

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| *Company* | *Comments* |
| Samsung | We would suggest to try to make more progress – i.e. either agreeing FFS or eliminating FFS that are not agreeable - at this meeting (probably after this round).  As is, the above proposal is practically unnecessary on top of CP3.1 (it just lists FFS but there is nothing to FFS, only to decide) – in that sense, it can be deprioritized.  Moderator comment: The FFS is to be resolved by agreeing on CP 3.4 (see below) |
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**Proposal CP 3.3:** **Support PHY priority handling for a PUCCH carrying the Rel-16 Type 3 HARQ-ACK CB in Rel-17.**

* **The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-16 Type 3 HARQ-ACK CB.**
* **The A/N of HARQ processes is mapped to the Rel-16 Type 3 HARQ-ACK CB irrespective of the PHY priority of the ‘A/N’ of the HARQ processes.**
* **The support is subject to a Rel-17 UE capability and a UE supporting this capability can be configured in Rel-17 with Rel-16 Type 3 HARQ-ACK CB and PHY prioritization.**

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| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Sony, Intel, Sharp, DOCOMO, Samsung, Qualcomm, ETRI, NEC, CATT, China Telecom, FGI/APT, LG, Huawei, Ericsson, Spreadtrum, Mediatek |
| Objecting companies |  |

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| *Company* | *Comments* |
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On the codebook for PHY priority handling discussed in Question 3.2, a strong majority suggested to only support a single structure / size (i.e. Alt. 1) whereas as subset of Alt. 1 companies also support Alt.2 with nobody indicating Alt. 3 or Alt. 4. Therefore it is proposed to agree to Alt. 1. Input from the 1st round included, by removing companies that indicated both Alt. 1 and Alt. 2.

**Proposal CP 3.4: For the PHY priority handling of the enhanced Type 3 CB(s) of smaller size, the enhanced Type 3 HARQ-ACK has the same structure, size and content (in terms of HARQ-IDs, CCs) irrespective of the PHY priority.**

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| Supporting companies | OPPO, Panasonic, Sony, Intel, Sharp, Samsung, DOCOMO, ETRI, NEC, CATT, LG, Huawei, Spreadtrum, vivo, Mediatek |
| Objecting companies |  |

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| *Company* | *Comments* |
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On the DCI format utilization for R16 and R17 Type 3 CB, all companies support proposal 3.5 and 3.6 from the first round. Therefore, these proposals are brought forward to be agreed:

**Proposal CP3.5:** **Support Rel-17 enhanced Type 3 HARQ-ACK CB of smaller size triggering using DCI format 1\_2 for a UE supporting DCI format 1\_2.**

* **The triggering support for DCI format 1\_2 is independently (from triggering using DCI format 1\_1) RRC configured to the UE.**

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| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Sony, Intel, DOCOMO, Samsung, Qualcomm, ETRI, NEC, CATT, China Telecom, FGI/APT, Huawei, Ericsson, Mediatek |
| Objecting companies |  |

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| *Company* | *Comments* |
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**Proposal CP3.6:** **Support Rel-16 Type 3 HARQ-ACK CB triggering using DCI format 1\_2 in Rel-17 for a UE supporting DCI format 1\_2.**

* **The support is subject to a Rel-17 UE capability and a UE supporting this capability can be configured with DCI format 1\_2 triggering of the Rel-16 Type 3 HARQ-ACK CB.**

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| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Sony, Intel, DOCOMO, Samsung, Qualcomm, ETRI, NEC, CATT, China Telecom, FGI/APT, Huawei, Mediatek |
| Objecting companies |  |

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On the handling of HARQ-ACK information that cannot be mapped to the enh. Type HARQ-ACK codebook of smaller size in Question 3.3. a majority of companies prefers that the UE is not expecting such case to keep it simple. The related proposal is therefore brought forward here:

**Proposal CP3.7: For the enhanced Type 3 HARQ-ACK CB of smaller size triggered in a PUCCH slot, the UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook.**

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| Supporting companies | vivo, Sony, Samsung, Qualcomm, CATT, LG, Huawei, Lenovo/Motorola Mobility, Ericsson, China Telecom, Intel |
| Objecting companies | OPPO (Not object, just for clarification) |

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| *Company* | *Comments* |
| Samsung | We would suggest to focus on defining the “cannot be mapped” – i.e. conditions/timeline/… as this is the main thing needed (i.e. should try to also progress this proposal).  Moderator comment: what cannot be mapped is tried to be clarified already with the last words there of the proposal,   **that cannot be mapped to the enhanced Type 3 HARQ-ACK CB of smaller size as the HARQ process is not part of the codebook**  Timeline for HARQ mapping to PUCCH is not changed according to moderator view |
| OPPO | Just clarification for proposal CP 3.7  When both Type 1 HARQ-ACK codebook and enhanced Type 3 HARQ-ACK codebook are configured and Type1 HARQ-ACK codebook contains HARQ-ACK information for all configured CCs but enhanced Type 3 HARQ-ACK codebook contains HARQ-ACK information for a subset of configured/activated CCs or HARQ process, then to avoid HARQ-ACK information in Type 1 HARQ-ACK codebook but not in enhanced Type 3 HARQ-ACK codebook transmitting, enhanced Type 3 HARQ-ACK codebook can be trigged only in the slot without Type 1 HARQ-ACK codebook.  If our understanding is correctly, we are not sure whether it is deserved to introduce additional latency to avoid Type 1 and enhanced Type 3 HARQ-ACK codebook collision.  Moderator: the scheduling restriction pointed here would be the consequence. If the gNB does not want to have this, of course the gNB can either use Rel-16 Type 3 CB (not having this issue). |
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**One-shot triggering related proposals:**

The triggering indication of PUCCH occasions / codebooks in the triggering DCI received only support by companies in Round 1 of Proposal 3.7. Therefore, this is suggested to be agreed:

**Proposal CP3.8:** **The DCI triggering (by a DL assignment) the one-shot HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB** **dynamically indicates the HARQ-ACK codebook(s) / PUCCH occasions to be re-transmitted.**

* ***FFS details***

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| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Sony, ZTE, DOCOMO, Samsung, Qualcomm, NEC, CATT, China Telecom, FGI/APT, LG, Lenovo/Motorola Mobility, Huawei |
| Objecting companies |  |

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| *Company* | *Comments* |
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Looking at the input given to Question 3.4, the strong majority of companies think a single triggering DCI should only trigger the re-transmission of a single PUCCH occasion / HARQ-ACK CB because of simplicity and the unclear neeed whereas only 3 companies think, a single triggering DCI could trigger the re-transmission of HARQ-ACK information of more than one PUCCH occasion. Therefore, it is suggested to agree to the following:

**Proposal CP 3.9: A single DCI triggering the Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB can trigger the re-transmission of HARQ-ACK information of only a single HARQ-ACK CB.**

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| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Sony, Sharp, Samsung, Qualcomm, ETRI, CATT, China Telecom, FGI/APT, Huawei |
| Objecting companies | Lenovo/Motorola Mobility |

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| *Company* | *Comments* |
| ZTE | Not strongly object the proposal. Just to say that the overhead will be reduced by one DCI to indicate re-transmission of multiple HARQ-ACKs compared with multiple DCIs. This is compatible for single DCI case. |
| Lenovo/Motorola Mobility | We think triggering retransmission of a single HARQ-ACK CB only is unnecessary restriction and potentially increases DCI overhead. |
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There had been different proposals on how to trigger indication ‘by a DL assignment’ is done. Looking at the input received in Question 3.5, it seems to be clear that Alt. 1 should be selected (for simplicity) based on the strong majority. Therefore, the following is proposed:

**Proposal CP3.10: The Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB is done through an explicit triggering indication in the DCI through a DCI field ~~(as for enh. Type 2 and Type 3 CB)~~.**

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| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Sony, ZTE, Samsung, DOCOMO, QC, ETRI, NEC, CATT, FGI/APT, LG, Huawei, Lenovo/Motorola Mobility, Ericsson, China Telecom |
| Objecting companies |  |

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| *Company* | *Comments* |
| Samsung | We suggest to remove the “(as for enh. Type 2 and Type 3 CB)” - it is more confusing than explanatory.  Moderator: can remove – changed. |
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Also the PHY priority handling of Proposal 3.8 only received support, and is therefore suggested to be agreed:

**Proposal CP3.10:** **Support PHY priority handling for the Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB.**

* **The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the re-transmitted HARQ-ACK information.**
* **The indicated PHY priority in the triggering DCI is used to determine the HARQ-ACK information to be re-transmitted corresponding to the indicated PHY priority.**

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| Supporting companies | Nokia/NSB, OPPO, Panasonic, Sony, ZTE, DOCOMO, Samsung, QC, ETRI, NEC, CATT, FGI/APT, Huawei, Ericsson, vivo, China Telecom |
| Objecting companies |  |

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| *Company* | *Comments* |
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* 1. 2nd Round and 3rd round of email discussions

**Type 3 CB related:**

On proposal 2.1 from round 1, if dynamic triggering of one of multiple codebooks is to be supported, this seems to not an issue which can be solved by any checkpoint, but may need some online GTW time to select between the two alternatives. I therefore copy here a new question, which is to reflect the input given to proposal 2.1 (i.e. companies that did not support the proposal prefer a single enh. Type 3 HARQ-ACK codebook. Further input if needed is appreciated, but the moderator has the feeling that really some GTW decision will be needed.

**Question 3.4.1: For enh. Type 3 HARQ-ACK CB(s) of smaller size,**

* **Alt. 1: Support dynamic selection based on indication in the triggering DCI of one of multiple enh. Type 3 HARQ-ACK CB(s) of smaller size.** 
  + **Each of the multiple CBs is** **at least defined by RRC configuration (FFS based on activation)**
  + **Details are FFS**
  + **Supporting companies:** Nokia/NSB, OPPO, vivo, Intel, Sharp, DOCOMO, Samsung, Spreadtrum, ETRI, NEC, LG, Apple
* **Alt. 2: Only a single enh. Type 3 HARQ-ACK CB(s) of smaller size is active at a time**
  + **The CB is at least defined by RRC configuration (FFS based on activation)**
  + **Details are FFS**
  + **Supporting companies:** Ericsson, Sony, Qualcomm, CATT, Huawei, Lenovo/Motorola Mobility

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| *Company* | *Comments* |
| QC | Alt 2.  With regards to Alt 1  Not a very constructive approach from the moderator: 5 companies objected the proposal with the solid reasoning of Alt 1 increasing complexity and going against the intention to have a simple solution for the Enhanced Type 3 CB.  Having this situation in hand, the impartial approach would have been to make separate proposals for Alt 1 and Alt 2 and see how many companies object Alt 2.  Moderator: Getting over time slightly tired of QC’s continuous unfounded accusations over the past meetings. Please refrain from doing so in the future.  There had been input to this meeting 10 companies proposing one thing, and 3 the other. What would you have expected the moderator to try in the first round? How would it have been to propose the rather large minority proposal 3 vs. 10 as a first try (please check the summary /situation at the beginning of the meeting)? |
| Xiaomi | Alt 1 is preferred |
| vivo | @Ericsson, Sony, Qualcomm, CATT, Huawei, Alt.1 will not increase the DCI size. Similar as other features like SCell dormancy, the existing field(s) in the DCI can be re-interpreted without scheduling PDSCH. In addition, one-short triggering for HARQ reTx also requires to re-interpret the existing DCI field if the same DCI size is kept.  About the complexity, did not see complexity difference between the one-short triggering and enhanced Type 3 CB with more than one smaller sizes since both mechanisms require to re-interpret some fields in the DCI. |
| Intel | We don’t consider eType3 CB and one-shot triggering to be complementing each other, thus eType3 CB is preferred to have the capability of dynamic switching between at least two different configurations. |
| Sony | We do not really see the point of multiple e-Type 3 CBs for the sake of trying to adapt to the dynamically changing number of dropped HARQ-ACK. If size is an issue, there is a far more elegant solution, i.e. use the new dynamic CB (the one-shot trigger that is not Type 2 or Type 3 CB). |
| Huawei | The question here is enhanced type 3 CB with RRC configured size already provides flexibility, and it is no strong motivation to introduce a new field in the DCI for which we need to take more effort on discussing its size, whether/how to reuse the legacy bit field, etc. On the other hand, as we have also introduced one-shot triggering of the HARQ-ACK retransmission, the network will have diversified and flexible methods to tackle different HARQ-ACK dropping cases. Thus further optimization is not so necessary from our view. We recommend the proposal could be modified as below:  **For enh. Type 3 HARQ-ACK CB(s) of smaller size, at least consider a single enh. Type 3 HARQ-ACK CB(s) of smaller size is active at a time.**   * **The CB is at least defined by RRC configuration (FFS based on activation)** * **Details are FFS** * **FFS dynamic selection based on indication in the triggering DCI of one of multiple enh. Type 3 HARQ-ACK CB(s) of smaller size.**   Moderator: I guess with this proposal it will be the other way around. I see the only option on this one to go with two Alternatives the GTW session and decided there. If we agree with this, we will have the same situation on the FFS point. |
| Mediatek | Alt-2  Simpler solution from UE implementation perspective. |
| Apple | Alt-1: since it is for URLLC, L1 priority should be considered for eType3. |
| QC | Very valuable point from Vivo. Even if the existing DCI bits can be interpreted in a different way and the existing DCI fields can be reused, the network has to indicate how the DCI fields should be interpreted. The complexity is mostly on the UE side – as mentioned by Mediatek – since the UE will have to be prepared to transmit variable sizes of Enhanced Type 3 CB from slot to slot. |
| Lenovo/Motorola Mobility | Alt2 preferred. If many different combinations of retransmission need to be supported, it’s better to use a new dynamic codebook for retransmission of cancelled HARQ-ACK. |

Looking at the input given to Question 3.1, which enh. Type 3 CBs could be supported, the following can be noted:

* Alt. 1 to Alt. 4 are supported by at least 4 companies, with Alt. 1 and Alt. 2 received most support
* Alt. 6 is only supported by 1 company – suggestion to not consider further
* Alt. 7 & 8 is not supported by any company – suggestion to not consider further

Please note, that we could support from specification point of view more codebooks, also if only a single one could be active at a certain point. Therefore, the decision to support more than one is not related to dynamic indication. Therefore, moderator suggest the following proposal:

>> Revision from moderator for Round 3, see arguments in the table. With the reduced set to 3, could this be acceptable (companies encourage to consider their objection).

**Modified Proposal 3.4.1: The following enhanced Type 3 CBs of smaller size are supported, the CB to contain:**

**1. the HARQ processes of a subset of configured CCs**

**2. a subset of configured HARQ processes (specific to CCs)**

**3. the HARQ processes of only activated CCs**

**~~4. the SPS HARQ processes of configured SPS processes~~**

**~~5. the SPS HARQ processes of activated SPS processes~~**

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| Supporting companies | NEC, QC, LG, OPPO, Intel, Nokia/NSB, DOCOMO, Samsung (cases 1 and 2), Xiaomi |
| Opposing companies | CATT, Sony, Huawei, Intel (add 4 or 5 back) |

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| *Company* | *Comments* |
| DOCOMO | We support #1, #2) and #3. For #4 and #5, we think they belong to #2 by gNB configuring the sub-set of HARQ processes which may be used for certain SPS processes. In our understanding, gNB may configure HARQ process number offset for each SPS configuration, instead of explicit HARQ process number (set) for each SPS configuration. The actual HARQ process number is determined based on the configured HARQ process offset and position of the SPS PDSCH. |
| CATT | It is our understanding that 1 and 4 can be achieved by 2 so that we think 1 and 4 are not needed. For 5, we think there may be potential misalignment between gNB and UE in terms of enhanced Type 3 CB size if activation/release DCI is missed at UE side. So we support 2 and 3 only. |
| OPPO | Above alternatives can be converged further:   * Alt 4,5 can be regarded as a special case for Alt 2. To be specific, a subset of HARQ process in Alt 2 is configured by SPS HARQ process ID of configured/activated SPS configurations, then Alt 2 is exactly Alt4/5, especially when only one enhanced Type 3 HARQ-ACK codebook is configured. * Similarly, Alt 3 is a special case for Alt.1.   So we suggest to converge to two types:  **1. the HARQ processes of a subset of configured CCs**  **2. a subset of configured HARQ processes (specific to CCs)** |
| Intel | Agree with the set, but also fine to streamline further |
| Sony | Alt-4 and Alt-5 are **NOT Type 3 CBs**. We made this Working Assumption regarding Type 3 CB:   * *Definition of enhanced Type 3 CB:*    + *The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration*   + ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***   The traditional Type 3 CB basically have a list of fixed HARQ-IDs and serving cells arranged in a specific order. So my question to Alt-4 and Alt-5, how does the gNB knows which HARQ-ID to configure for these activated SPS since the HARQ-ID of the SPS is dynamically determined?  This question in a way is also relevant for Alt-2. |
| Huawei | As the vast majority of companies are supporting Alt.1 and Alt.2, maybe these two alternatives should be kept, thus the spec effort can be relieved. |
| Mediatek | Alt-1 is simpler to support. |
| Apple | A subset of HARQ processes at a CC can be supported also, so the feature remains useful for the single CC case. |
| Moderator update for 3rd round | It seems that specifically 4 & 5 are contentious, so let’s remove them and see if we could converge on Alt. 1 to 3. |
| Huawei | As all the three methods semi-statically configure the Type 3 CB, Alt.1 and Alt.2 may provide enough flexibility and Alt.3 seems not so necessary. |
| Nokia/NSB | As Huawei, we think that Alt. 1 & 2 could be sufficient, but would not object to including Alt. 3 as well (if there is strong support). |
| QC | What is the intention with this question? To delineate the content of Re. 17 Type 3 HARQ CB in terms of HARQ Process IDs to be included? If this is the case, it the intention that Rel. 17 Type 3 HARQ CB 17 Type 3 HARQ CB contains HARQ Process IDs from “(sub)sets of configured HARQ processes within (sub)sets of configured CCs”? These (sub)sets of configured HARQ processes can contain DG PDSCH HARQ or SPS HARQ?  Moderator: Yes – this is the intention. To check with ‘Types’ of enh. Type 3 CB should be supported. Meaning, how many different RRC configuration structures for different ‘enh. Type 3 CB types’ we may need to support. Alt. 1 needs configuration structure in terms of serving cell index only, Alt. 2 may need a bitmap per serving cell index, Alt. 3 just needing a single RRC parameter.  These subsets are still HARQ process based, so the A/N mapping should not distinguish in the mapping between different HARQ types (DG PDSCH, SPS HARQ, activation, release,…) |
| Lenovo/Motorola Mobility | We only support case 1 and case 2. |
| DOCOMO2 | We are fine with Alt 1, 2 and 3. In our understanding, Alt 3 is more flexible than Alt 1 because the HARQ-ACK CB is impacted by Scell activation/de-activation MAC CE . But we are also flexible to preclude Alt 3 if companies have concern on it. |
| vivo | We are fine to include only Alt.1 and Alt.2. |
| CATT | Why Alt. 1 is needed if Alt. 2 is supported? |
| Samsung | Support cases 1 and 2.  Using only activated CCs, instead of configured CCs, is something to be considered in general, both for codebooks (especially for Type-1) and for PDCCH monitoring. Also, given cases 1 and 2, the need for considering only activated CCs for eType-3 is small. |
| NEC | We are fine with Alt.1, 2 and 3. But we prefer to keep FFS for Alt.4 until consensus on enhanced Type-3 CB determination based on RRC configuration or dynamic indication is made.  In our understanding, when a SPS configuration is activated, HARQ process set of SPS PDSCH occasions of the SPS configuration can be determined at UE side based on the first SPS PDSCH reception occasion, periodicity and HARQ process offset. If enhanced Type-3 HARQ-ACK CB size for Alt.2 is determined based on dynamic indication, Alt.4 is a special case of Alt.2, agree to remove the Alt.4.  If enhanced Type-3 HARQ-ACK CB size for Alt.2 is determined based on RRC configuration only, when gNB wants to trigger SPS HARQ-ACK retransmission of a SPS configuration, for Alt.2, gNB may need to configure multiple HARQ process sets, while gNB can directly indicate SPS configuration index in the triggering DCI for Alt.4. In this case, Alt.4 is more flexible than Alt.2, it is beneficial to support Alt.4 independently. |
| Intel | We probably missed the moment when 4 and 5 were struck out. At least one of those should remain, since in our understanding SPS HARQ-ACK dropping due to dynamic conflicts was one of the motivations for agreeing eType3 CB. |
| Xiaomi | At least alt 1 and alt 2 should be included. |

* 1. 4th round of email discussions

**Single or multiple enh. Type 3 CBs active at a time (i.e. fixed or dynamic indication):**

There been long discussions of the two alternatives of the following proposal from the GTW session:

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| **Proposal X: For enh. Type 3 HARQ-ACK CB(s) of smaller size, down-select from the following**   * **Alt. 1: Support dynamic selection based on indication in the triggering DCI of one of multiple enh. Type 3 HARQ-ACK CB(s) of smaller size.**    + **Each of the multiple CBs is at least defined by RRC configuration (FFS based on activation)**   + **Details are FFS** * **Alt. 2: Only a single enh. Type 3 HARQ-ACK CB(s) of smaller size is active at a time**   + **The CB is at least defined by RRC configuration (FFS based on activation)**   + **Details are FFS** |

Intel brought up as a compromise, to go with Alt. 1 but restrict the number of enh. Type 3 CBs to two at a time.

But it seemed, that companies wish to discuss a bit more overall, so let’s look at some of the aspects here that had been brought up:

* The main argument for Alt. 1 are increased flexibility by having the ability to choose one of M enh. Type 3 CBs, where therefore the size of each of them could be therefore smaller. Just having a single will reduce the useful-ness of the feature, specially compared to Rel-16 Type 3 CB.
* One argument against Alt. 1 is that one-shot triggering is the better choice. Maybe it is not worth discussing this claim / arguments here, as also discussed today, otherwise, RAN1 should have decided to only support one-shot triggering (but did not do, as it had been a compromise considering the larger support by companies for enh. Type 3 CB).
* One arguments against Alt. 1 is UE complexity, as based on dynamic indication in the DCI the UE would need to generate the enh. Type 3 CB. That said, the UE anyhow cannot have the full enh. Type CB ready, as based on the timing of the triggering the entries (depending on the scheduled PDSCH operation would be changing). So there is clearly some increase in UE complexity, but not to full extend.
* Another argument brought against Alt. 1 was testing complexity. The testing complexity is dependent on the number of enh. Type 3 CB types (see questions discussions around Proposal 3.4.1 above) that are supported. But the testing effort should not be increased if more than one enh. Type 3 CB of the same type (e.g. 2 or more Alt. 2 enh. Type 3 CB) are configured for dynamic indication.
* And finally, there was the DCI overhead. The moderator thinks that specifically this could be discussed here, specifically also looking at the potential compromise agreement that Mr. chairman brought today.

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| *Company* | *Comments* |
| Nokia/NSB | Agree with the moderator analysis |
| DOCOMO | Alt 1 first preference, fine with Alt 2 for compromise.  From flexibility perspective, we think Alt 1 is better. And we agree the number of smaller type 3 CBs should be limited. If companies have strong concern on Alt 1 from UE complexity, testing complexity and useful-ness perspectives, we are flexible to accept Alt 2. |
| vivo | We fully agree with moderator above observations. By enhanced Type 3 with limited number of sizes (2 or 3), not only the smaller size matters, it also gives more flexibility for the NW side to decide which one to trigger. |
| Samsung | Alt. 1.  We don’t think Alt. 2 can work with dynamic scheduling, CA, or with SPS where the HARQ process used is time-variant (slot-dependent). Alt. 2 can also be realized by Alt. 1 if a NW so prefers (e.g. providing a single CB configuration by RRC). We do not see any complexity issue from having a configurable field in the DCI indicate a configured CB. |
| Xiaomi | Agree with the moderator analysis |
| OPPO | Alt 1, agree with moderator analysis  Taking HARQ-ACK payload size reduction, DCI overhead increasing is deserved. For example, there are two activated DL carriers for UE, where each carrier is configured by 32 HARQ processes. If two enhanced Type 3 can be configured for two carrier separately, then HARQ-ACK payload size can be reduced by half, i.e. from 64bits to 32bits. In this case, 2-bit increase in DCI provides 32-bit reduction in UCI. PUCCH coverage and reliability can be improved significantly. |
| Sony | We prefer Alt-2. Enh-Type 3 CB is argued to have higher robustness than one-shot DCI CB (albeit this is debatable) and for such cases, size doesn’t matter. But if size does matter, one-shot DCI CB is significantly less complex and more efficient. Also as pointed out by other companies and listed in the points above, Alt-1 does not come for free, there are UE & testing complexities.  On Alt-1 DCI size, some argued that the triggering DCI cannot scheduled PDSCH so that the bits used for scheduling is used to indicate one of many Enh-Type 3 CBs. This would basically limit PDSCH scheduling opportunities. Unless the indication can be implicit or based on some rules, otherwise DCI size will be impacted. |
| MediaTek | We supported Type 3 for re-Tx of dropped HARQ (LP of HP) because it is an existing feature that can be directly utilized for URLLC. We are fine to have simple improvement to Type-3 by reducing the size using some high layer configuration. We don’t see a need for the dynamic change for the size reduction, given the added UE complexity and the lack of use-case.  If the argument is about having eMBB and URLLC services at the UE, and these services may require different sizes, **at most one enhanced Type-3 CB can be configured in addition to the legacy R16 Type-3 CB** for this case. Therefore, the gNB can request HARQ re-TX based on eType-3 (e.g. for URLLC service) or based on legacy R16 Type-3 (e.g. for eMBB service). Thus, even if Alt-1 is adopted, the dynamic selection must be between eType-3 (with smaller size) and legacy Type-3. |
| Intel | Our main concern with Alt.2 that when this feature is activated/configured, there is a sub-set of HARQ IDs / cell IDs which could not be retransmitted. To avoid this, the network would configure the full Type 3 CB.  Thus Alt.1 is preferred. We are also open to limiting the number of CBs that are switchable to 2 or 3 (subset A, subset B, subset A + B). |
| Lenovo/Motorola Mobility | Support Alt 2. We prefer not to complicate UE implementation and not to overly optimize one feature (i.e. enhanced type3 CB) for duplicated functions with another feature (i.e. one-shot triggering). |
| Huawei/Hisi | We can be flexible to Alt.1 for the progress. |
| Panasonic | We agree with the moderator’s analysis. Alt.2 is our first preference, but we are flexible to accept Alt.1. |
| LG | Agree with the moderator analysis and we supported Alt. 1 |
| ZTE | We can support Alt.1 |
| Spreadtrum | Alt 1 first preference, fine with Alt 2 for compromise. |
| QC | First of all:  Request (to moderator and Enh. Type 3 opponents): respect the groups judgement/opinion. As a reminder here (below) is the list of companies supporting Enh. Type 3 CB and “1 shot triggering” at the last #105e meeting. The excerpt is taken from the moderator’s report [R1-2106248] – based on moderator’s counting, the numbers are obvious. Moreover, respect that the group has already been spending a lot of time for 3 meetings now in discussing details of Enh. Type 3 CB and of “1 shot triggering” and it is not a constructive approach to go back to an already agreed topic and eventually erase everything.   * **Alt. 1 (18 Yes – 3(2?) No)- Support enhanced Type 3 CB(s) with smaller size (compared to Rel-16):**    + **Yes:** Ericsson [1], HW/HiSi [2] (based on RRC configuration only, but not essential), Nokia/NSB [3], vivo [5], Spreadtrum [6], CATT [7], QC [9], OPPO [10], China Telecom [11], Intel [12], Apple [13], Panasonic [15] (but not essential), ETRI [16], Interdigital [19], LGE [20], DoCoMo [22], Moto/Len [25] (no triggering needed), WILUS [27]   + **No:** Sony [14], Samsung [18] (unnecessary / not meaningful), Mediatek [23] (reuse as is)(?) * **Alt. 3 (9(?)(8) Yes – 2 No) – DCI scheduling new PUCCH resource for HARQ re-transmission / One-shot triggering of dropped HARQ-ACK on PUCCH:**   + **Yes:** Nokia/NSB [3], ZTE [4], CATT [7] (‘if supported’, see detail below)(? CATT to confirm), OPPO [10], Sony [14], Samsung [18], DoCoMo [22] (if time window for Type 3 CB not supported), Mediatek [23], Ericsson[1]   Note: the working assumption of #105e was a compromise for the Enh. Type 3 CB camp, that accepted a secondary solution, like the “1-shot HARQ feedback” without any details.  Reply to question:  With regards to UE complexity, we support Mediatek and other companies that explained in detail the increase in UE complexity during the session and in their replies in previous rounds. The moderator’s comment above “the UE anyhow cannot have the full enh. Type CB ready, as based on the timing of the triggering the entries (depending on the scheduled PDSCH operation would be changing).” indicates that the issue is not clearly perceived. The increase in complexity and in implementation is not negligible.  The same argument as for UE complexity applies for the testing effort. Moderator’s comment is not valid and therefore deleted. The discussion is not about comparing between   * 2 Enh. Type 3 CBs sizes with * more than 2, e.g. 4 or 8 Enh. Type 3 CBs sizes   but comparing   * a single (1) Enh. Type 3 HARQ CB sizes with * 4 or 8 Enh. Type 3 HARQ CB sizes   With regards to the DCI overhead, Alt 1 adds 2 or 3 more extra bits in the DCI. This implies the UE can be configured with 4 or 8 Enh. Type 3 CB sizes. In case DCI 1\_x does not schedule PDSCH, the overhead is very large.  Alt 2.  Enhanced Type 3 HARQ CB can be used for several occasions, e.g.   * SPS PUCCH collision with DL * PUSCH + HARQ cancelled with CI * LP HARQ dropped due to intra-UE mux   Hence, very likely, in most of the cases, the whole size, or something close to the Enh. Type 3 HARQ CB size will be used. The empty entries of the Enhanced Type 3 HARQ CB can be filled with new HARQ bits.  There has been a proposal for some meetings now that Enh Type 3 CB can be entirely dynamic: the gNB indicates the HARQ Process IDs requested and the Enh. Type 3 CB size is flexibly. This solution, being the ideal one, would have required a significant DCI overhead. The group having decided to opt for simplicity with regards to this Enh. Type 3 HARQ CB, alt 2 is the option preferred.  As also mentioned at the GTW session, this topic is of secondary priority for the feature. Of the highest importance are:   * How the Enh. Type 3 CB size will be defined * What would be the Enh Type 3 CB content, namely which HARQ processes are going to be used as input * How to fill the Enhanced Type 3 CB HARQ entries which are not mapped to cancelled HARQ bits   Once these details are set for a single Rel. 17 Type 3 HARQ CB, then, the discussion can open for multiple Rel 17 Type 3 HARQ CBs.  Question: for alt 1, useful to clarify if the difference between multiple configured Enh Type 3 HARQ CBs is only the size.  Moderator: it is not up to the companies to change the main text here. If you think you want to comment please do so. BUT DO NOT CHANGE the main text or any proposals or in this case the moderator assessment, as otherwise, the discussions and inputs by companies given earlier may not be reflected correctly! You may not agree with the moderator’s assessment, but then comment in here.  Reverted back to initial text before the question! |
| NEC | Alt.1 is preferred for flexibility. Agree with the moderator analysis. |
| CATT | We prefer Alt. 2.  We share the same understanding as Sony and MediaTek that the enhanced Type-3 HARQ-ACK codebook was supported due to its reliability and due to it is an existing mechanism. We should not over-optimize eType-3 HARQ-ACK CB especially it is known that the efficiency would not be good anyway.  With Alt. 1, it is not clear how gNB would configure the multiple CBs since gNB cannot predict the scheduling. In order to match the scheduling as much as possible, gNB should configure a number of CB(s). However, it is acknowledged by companies that supporting too many CBs would complicate the design, UE implementation and testing. However, if we limit the number of configured CBs, e.g. to 2, the benefit of Alt. 1 compared with Alt. 2 would be marginal since it is very unlikely that the configured CB can match the gNB scheduling. |
| Apple | Support Alt. 1 so it is a complete solution |

For the following discussions, the moderator assumes that there is an explicit triggering indication using a field in the DCI (as for Rel-16 Type 3 CB). So there is a way

**Question: In case the dynamic selection of enh. Type 3 CB is supported (i.e. Alt.1), which of the following alternatives do you support:**

* **Option 1: There is an *N*-bit DCI field for triggering included, one state indicating ‘not trigger’ whereas the remaining signalling states can be used to indicated one of up to *M* different enh. Type 3 CBs. *N* is defined as N=⎡log2 (M+1)⎤**
  + ***Note: for this operation the DCI overhead is increased for M>1 compared to Alt. 1, but this allows to trigger the enh. Type 3 CB and scheduled PDSCH with the same time DCIO***
  + ***Note: a restriction to a maximum of 2 enh. Type 3 CBs as discussed in GTW would not be using the signaling space optimally. Supporting up to 3 would lead to the same DCI overhead of 2bits***
  + ***Note: if only one enh. Type 3 CB is configured (i.e. M=1) there is no additional overhead***
* **Option 2: There is a 1-bit triggering DCI field (as for Rel-16 enh. Type 3 CB).** 
  + **If one a single enh. Type 3 CB is configured (M=1), the triggering DCI can schedule also a PDSCH, which corresponds to Option 1 of Alt. 1 and Alt. 2.**
  + **If more than one enh. Type 3 CB are configured (i.e. M>1), and DCI field indicates the triggering, the DCI cannot be used to scheduled PDSCH and some unused field (e.g. HARQ ID, PDSCH FDRA,…) is used to indicate the enh. Type 3 CB to be triggered.**
  + ***Note: for this operation the DCI overhead is not compared to Alt. 2, but for M>1 this does not allow to trigger the enh. Type 3 CB and scheduled PDSCH with the same time DCI***
  + ***Note: a restriction to a maximum of 2 enh. Type 3 CBs as discussed in GTW does not really decrease the DCI overhead***
* **Option 3: Other**

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| Option 1 | Vivo,OPPO, LG, Apple |
| Option 2 | Nokia/NSB, DOCOMO, vivo,Xiaomi, Intel, Huawei/Hisi, Panasonic, LG, ZTE, NEC |
| Option 3 | Sony |

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| *Company* | *Comments* |
| Nokia/NSB | We prefer option 2, as this will not further increase the DCI size and therefore could support also more than two enh. Type 3 CBs. |
| vivo | We are open for the both options in order to make the enh. Type 3 CB useful. |
| Samsung | Those details can be a next step. Both “option 1” and “option 2” exist in R16 for SCell dormancy indication. Option 1 is fine if the number of CBs is small (e.g. 3) and option 2 can be considered otherwise. |
| OPPO | Taking restriction on enhanced Type 3 HARQ-ACK codebook number, N is a small value, e.g. 2. So simple solution, e.g. option 1, is preferred. |
| Sony | We would prefer not to have dynamic indication of one of multiple Enh-Type 3 CBs. But if we decide to take this path, then we prefer that we explore some implicit indicators and not increase DCI size or compromise on PDSCH scheduling opportunities. |
| Intel | Prefer Option 2 which does not increase DCI overhead comparing to R16 Type 3 CB. |
| Lenovo/Motorola Mobility | Option 2 does not really reduce DCI overhead but may increase the overall DCI overhead, since scheduling PDSCH and triggering enhanced type3 CB cannot be done simultaneously via one DCI. |
| Huawei/Hisi | Option 2 is helpful to alleviate the DCI overhead and could be regarded as a compromise option between Alt.1 and Alt.2 |
| LG | We don’t have strong view between Option 1 and Option 2. If M is low, both Option 1/2 can be considered. |
| QC | The group needs to decide first if dynamic selection of Enh. Type 3 HARQ CB is selected. |
| NEC | Option 2 is slightly preferred because it does not increase DCI overhead. |

**Question: What additional restrictions on Alt. 1 could be done to take the worries of Alt. 2 camp into account?**

* **Option 1: Limit the number of enh. Type 3 CBs configured for the UE (as discussed in GTW, if you think so, please also provide a number)**
* **Option 2: Limit the number of enh. Type 3 CB types / structures (see Proposal 3.4.1) that can be configured for the UE at a time (e.g. only a single enh. Type 3 CB type /structure can be configured, but multiplex of the same type / structure)?**
* **Option 3: Other**

|  |  |
| --- | --- |
| Option 1 | DOCOMO, Intel (2 or 3 depending on exact signalling design), ZTE(number = 1,2,3,4), Apple (2, with M=1/M=2 as UE capability) |
| Option 2 | DOCOMO, Nokia/NSB |
| Option 3 |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| QC | Again the same suggestion to the moderator: do not waste the group’s energy and time with questions on topics which will be void. The group might decide to adopt Alt 2.  A proposal on the topics to be treated with regards to Enh. Type 3 HARQ CB is made above. If the moderator wants to focus on other topics as well, or in general discuss new topics,  proposals of interest are:   * the automatic (re)transmission of cancelled via CI PUSCH + HARQ and the * automatic (re)transmission of LP dropped HARQ.   Bringing these topics into discussion will provide a complete solution to the case of “cancelled HARQ”. |
| Nokia/NSB | If the group is really worried about the overall specs impact of the feature, one option here would be to just the enh. Type 3 CB to be defined as ‘a subset of configured HARQ processes specific to a CC’, as this also enables the gNB to configure be all HARQ process of certain CCs (Alt. 1) as well as SPS processes of configured SPS configurations etc.  This means, there could be just different configured subsets for the UE, where the DCI is indicating one of them. This clearly would reduce the complexity (as argued by some companies) |
|  |  |
|  |  |
|  |  |

**Supported Type 3 CB structures:**

Looking at the feedback to Modified Proposal 3.4.1, it seems that several companies only agreed to Alt. 1 and Alt. 2 (where Alt. 1 could also be realized by Alt. 2). So maybe we could try to check, if we could at least agree by the end of the week on 1. & 2., and keep FFS is we support additional types still in Rel-17.

**Mod2 Proposal 3.4.1: The following enhanced Type 3 CBs of smaller size are supported, the CB to contain:**

**1. the HARQ processes of a subset of configured CCs**

**2. a subset of configured HARQ processes (specific to CCs)**

**~~3. the HARQ processes of only activated CCs~~**

**~~4. the SPS HARQ processes of configured SPS processes~~**

**~~5. the SPS HARQ processes of activated SPS processes~~**

**FFS: additional enh. Type 3 CB types**

|  |  |
| --- | --- |
| Supporting companies | Samsung, LG, Spreadtrum, CATT, OPPO, vivo, ZTE, ~~Intel~~, Panasonic, Nokia/NSB, Lenovo/Motorola Mobility, DOCOMO, Xiaomi, Sony, Huawei/Hisi, Apple |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Intel | We prefer adding alt 4. Note, that eType3 CB was agreed with one of the motivations to handle SPS HARQ-ACK dropping due to dynamic conflicts. In our understanding, SPS-Config configures both #HARQ processes and the HARQ process offset, that allows a UE to understand which processes to combine into the eType3 CB. |
| QC | Based on moderator’s feedback at the previous round here is the suggested wording:  **Mod2 Proposal 3.4.1: Enhanced Type 3 CB contains HARQ Processes being a set/sub-set of configured HARQ processes per CC within a set/sub-set of configured CCs. These HARQ Processes can be mapped either to DG or SPS HARQ Processes.**  **FFS: additional enh. Type 3 CB types**  Note: agreement with Intel. Hopefully the proposal covers Intel’s intention. |
| NEC | Agree with Intel’s views and we prefer to keep FFS for Alt.4.  As we mentioned above, when a SPS configuration is activated, both UE and gNB know the HARQ process set of SPS PDSCH occasions of the SPS configuration. If Alt.4 is supported, gNB can flexibly trigger an enhanced Type-3 CB including configured HARQ processes for SPS HARQ-ACK only of any one or more SPS configuration. It can achieve optimized eType-3 CB size. |
| CATT | Although we agree with the intention from Intel, we think it can be achieved by Alt. 2 since the set of HARQ processes for SPS PDSCH is known based on configurations. |
| Apple |  |

**Additional triggering discussions for Rel-17 one-shot HARQ feedback of HARQ-ACK**

For the one-shot triggering in Rel-17, we have agreed to have a dynamic indication to define which HARQ-ACK codebook is to be transmitted, that a single DCI can only trigger a single HARQ-ACK codebook to be re-transmitted and that we have the PHY priority indication supported, which should determine the HARQ-ACK codebook to be re-transmitted. Moreover, we further agreed that the re-transmission is explicitly triggered based on the following 4 agreements:

|  |
| --- |
| Agreement CP3.8:  The DCI triggering  (by a DL assignment) the one-shot HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB dynamically indicates the HARQ-ACK codebook(s) / PUCCH occasions to be re-transmitted.   * *FFS details*   Agreement CP 3.9:  A single DCI triggering the Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB can trigger the re-transmission of HARQ-ACK information of only a single HARQ-ACK CB.  Agreement CP3.10:  The Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB is done through an explicit triggering indication in the DCI through a DCI field ~~(as for enh. Type 2 and Type 3 CB)~~.  Agreement CP3.11:  Support PHY priority handling for the Rel-17 one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB.   * The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the re-transmitted HARQ-ACK information. * The indicated PHY priority in the triggering DCI is used to determine the HARQ-ACK information to be re-transmitted corresponding to the indicated PHY priority. |

The first question that arises here, is that when having explicit triggering indication in the triggering DCI agreed and moreover having agreed a dynamic indication of the HARQ-ACK codebook / PUCCH occasion agreed, how this is indicated in the triggering DCI. Based on the companies inputs to this meeting and some further alternative charting, the following could be at least considered:

**Question 3.5.1: Which of the following alternatives on the triggering details of the Rel-17 one-shot triggering do you support?**

* **Alt. 1: A 1-bit DCI field is used to support the explicit triggering indication. A separate N-bit DCI field is included in the DCI for the dynamic indication of the HARQ-ACK codebook / PUCCH occasion to be re-transmitted.** 
  + ***Note: N+1 bit DCI overhead. This enables the triggering DCI to schedule PDSCH at the same time.***
* **Alt. 2: A N-bit DCI field is included to the triggering DCI, where one state indicates ‘no triggering’ and the remaining 2^N-1 states are used for the dynamic indication of the HARQ-ACK codebook / PUCCH occasion to be re-transmitted.**
  + ***Note: N-bit DCI overhead. This enables the triggering DCI to schedule PDSCH at the same time***
* **Alt. 3: A 1-bit DCI field is used to support the explicit triggering indication. If the triggering DCI indicates ‘triggering’, the DCI is not scheduled PDSCH at the same time and some DCI field (such as the HARQ-ID field) is used for the dynamic indication of the HARQ-ACK codebook / PUCCH occasion to be re-transmitted.**
  + **Note: 1-bit DCI overhead. A triggering DCI indicating ‘1’ or ‘trigger’ does not support to schedule PDSCH.**
* **Alt. 4: Other**

|  |  |
| --- | --- |
| Alt. 1 |  |
| Alt. 2 | Lenovo/Motorola Mobility, FGI/APT |
| Alt. 3 | Nokia/NSB, DOCOMO, vivo,Xiaomi, Intel, Panasonic, ZTE, CATT |
| Alt. 4: | Sony, QC |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia, NSB | Prefer Alt. 3, as this does not increase the DCI size. This is especially of importance considering operation with compact DCI (i.e. DCI format 1\_2). |
| vivo | For one shot triggering, the majority view is to retransmit the entire ‘old’ HARQ-ACK codebook. If such one shot triggering can schedule the PDSCH, the codebook may need to be reconstructed as a ‘new’ codebook. In addition, in order to given sufficient time-offset range to indicate the old codebook, more than 2 bits are needed. To avoid DCI size increase too much, Alt.3 is preferred. |
| Samsung | Those details can be a next step. Alt.2 and Alt.3 are like “option 1” and “option 2” for eType3 – purpose/benefit of Alt.1 is not clear.  As a single HARQ-ACK CB is to be indicated for retransmission (should be enough in non-shared spectrum), Alt. 2 is sufficient. |
| Sony | We can just have 1 bit trigger and the UE just retransmit the CB of the last dropped PUCCH. If the last dropped PUCCH carries a Type 2 CB, then the DCI also indicates the last DAI of the last DL Grant corresponding to that Type 2 CB (to mitigate against DCI misdetection). Note here there is no increase in DCI size DL Grant for Type 2 CBs would anyway have the DAI bits in them.  If the dropped PUCCH carries Type 1 CB, then there really isn’t anything else to indicate apart from the 1 bit trigger.  Hence, all that is required is an additional 1 bit trigger.  Moderator: Please note that we decided to have a dynamic indication based on this agreement (and see the discussions there). And the text when discussions proposal 3.7 in the first round (which respect to just re-tx the last dropped).  ***Agreement***  *The DCI triggering (by a DL assignment) the one-shot HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB dynamically indicates the HARQ-ACK codebook(s) / PUCCH occasions to be re-transmitted.*  *FFS details* |
| Intel | Similar motivation as for eType3 CB triggering. |
| Lenovo/Motorola Mobility | We prefer to support scheduling PDSCH and triggering one-shot HARQ-ACK retransmission via one DCI. |
| ZTE | Here we discuss the indication of the HARQ-ACK codebook / PUCCH occasion, while another issue is also necessary to be considered. Due to the missing of DCI for initial PUCCH, the size of the corresponding codebook for retransmission would be ambiguous between gNB and UE, it is more seriously if Alt.2 in question 3.5.3 would be adopted. The DCI missing issue is not 100% solved in the specification for PUCCH transmission but solved by T\_DAI in UL grant when UCI is multiplexed into PUSCH. Then a similar and simple way could be considered in the R17 one-shot triggering retransmission, for example, by indicating the corresponding codebook size in one-shot DCI when the codebook is retransmitted. |
| QC | What is the source of these alternatives? Have they been proposed by a given company? All of them are far from being intuitive.  As mentioned by several other companies even Alt 1 will lead into error cases. The problem is described in the contribution: the UE might have missed the DCI scheduling the LP PDSCH HARQ CB, which is at the end requested. The UE is requested to transmit a HARQ CB that the UE does not have. What does the UE transmit? Nothing? 1 bit NACK?  The solution that resolves the ambiguity is that DCI requesting “1 -shot HARQ feedback” indicates the HARQ CB size as well.  Hence, the DCI would like this    This would imply that if 1 LP HARQ bit is dropped and the PUCCH or HARQ CB, or the slot offset numbering is done from 0-4, then 2 bits are needed for the CB or PUCCH ID. In case the HARQ CB size can be up to 16, then 4 bits are needed for HARQ CB size indication. In all, 2+4 = 6 bits are needed in this DCI so as to request 1 HARQ bit back.  The proposal is that the network sends a request to the UE (via DCI) asking for an indication of whether the UE has dropped or not a LP HARQ CB. The UE replies and this resolves the ambiguity of the “lost DCI”. The network can indicate the “last” or “earliest” cancelled HARQ CB in a predefined time window (configured at RRC). The only bit needed is for triggering the “1-shot HARQ feedback request”.  Below the proposal |

In addition, let’s assume we have X states or N bits available for the dynamic indication of the HARQ-ACK codebook / PUCCH occasion to be re-transmitted. There had been some companies proposing to use a bitmap for the indication, but as we have the decision available to only indicate a single HARQ-ACK CB / PUCCH occasion, using some more compact signaling using the X states or N bits signaling by mapping a single ‘PUCCH occasion’ to a single state of the X state or N bits seems to be more efficient. But all input contributions basically discussed some ‘PUCCH slot offset’ (in one way or the other), but first let’s discuss how this slot offset could be defined.

E.g. CATT proposed a PUCCH slot-offset between the PUCCH slot where the triggering DCI is received and the PUCCH slot, where the HARQ-ACK CB has been located. This is shown in the following Figure (borrowed from CATT). For the discussion here, the moderator uses the terminology ‘*PUCCH slot offset between the triggering DCI and the HARQ-ACK CB for re-transmission*’: 

As is visible from this Figure by CATT, in case the HARQ-ACK CB is earlier than the triggering DCI, then a negative value needs to be indicated (i.e. Offset=-1 for the example above), whereas if the triggering DCI indicates a re-transmission in a future slot (but as it had been clear already that this is to be dropped, e.g. due to HP overriding or UL CI, e.g. Offset=1, would indicate re-transmission from slot n+2 in slot n+3). Therefore, this method would require a combination of positive and negative values for the offset triggering, if early triggering is to be supported, as e.g. suggested by ZTE.

In contrast, e.g. Nokia proposed the offset to be counted from the new PUCCH slot backwards, which the moderator would like to denote as ‘*PUCCH slot offset between the new PUCCH slot for transmission and the HARQ-ACK CB for re-transmission’,* which is shown in the following Figure from Nokia:



In contrast to the definition by CATT, the values of slot-offset are independent of the triggering DCI timing and would be all negative values <-1 (as in the figure or all positive >1 if counting back), which could simplify the definition of the slot offset values (due to the independence of the triggering timing) and moreover, the maximum slot offset value would automatically define the maximum limitation of the maximum delay between originally intended and re-transmission timing.

**Question 3.5.2: On the definition of some ‘PUCCH slot offset’ for dynamically indicating the HARQ-ACK codebook(s) / PUCCH occasions to be re-transmitted:**

* **Alt. 1: the PUCCH slot offset defines the offset between the triggering DCI and the PUCCH slot of the HARQ-ACK codebook to be re-transmitted (see Fig. 4 from CATT above)**
* **Alt. 2: the PUCCH slot offset defines the offset between the new PUCCH slot for transmission and the PUCCH slot of the HARQ-ACK codebook to be re-transmitted (see Fig. 5.1 from Nokia above)**
* **Alt. 3: Other**

|  |  |
| --- | --- |
| Alt. 1 | Samsung, OPPO, Lenovo/Motorola Mobility, LG, ZTE, NEC, CATT, Sony, FGI/APT |
| Alt. 2 | Nokia/NSB, DOCOMO, vivo, OPPO, Panasonic |
| Alt. 3 |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | Prefer Alt. 2, as the value range of the PUCCH slot offset is independent of the triggering DCI (so not a mix of negative & positive values needed). Moreover, the indicate value of the slot offset basically limits the maximum delay between the initial PUCCH slot and the PUCCH slot for re-transmission. |
| vivo | It is simple to interpret the offset values all negative values. Besides, no operation for mixed numerology will be involved since only the PUCCH cell is considered for timing determination. |
| Samsung | Those details can be a next step.  Alt. 1 requires fewer bits than Alt. 2, in general – also, for Alt. 2, there will be a k1 indication in the DCI. One other thing to consider to limit the number of bits is for the indication to be for slots with PUCCH resources, not any slots (e.g. also DL slots). Then 2 bits should be sufficient, including the “no triggering” state. |
| Sony | The UE needs to just retransmit the last dropped PUCCH. Hence we do not think there is a need for indication.  However, if this is for reliability purpose, e.g. the UE somehow did not realise that there was a dropped PUCCH, then we prefer Alt.1.  Moderator: Please note that we decided to have a dynamic indication based on this agreement (and see the discussions there). And the text when discussions proposal 3.7 in the first round (which respect to just re-tx the last dropped).  ***Agreement***  *The DCI triggering (by a DL assignment) the one-shot HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB dynamically indicates the HARQ-ACK codebook(s) / PUCCH occasions to be re-transmitted.*  *FFS details*  @Moderator: Thanks for reminding. In that case we prefer Alt.1 |
| Intel | We don’t have strong preference between Alt.1 and Alt.2, since the difference is only in how the signalling is designed. |
| Huawei/Hisi | We are open to both alternatives. |
| LG | We don’t have strong view, however, it would be reasonable to take the reference near to target. DCI is always preceding PUCCH thus it would require smaller range of offset indication. |
| NEC | We are open to both alternatives. |
| CATT | We do not see how Alt. 2 simplifies the definition of the slot offset values. We do not understand the comment on mixed numerology either. In order to determine the PUCCH resource including slot in response to the triggering DCI, the numerology needs to be considered anyway.  We agree with Samsung that Alt. 1 requires fewer bits than Alt. 2 in general. |

The next step would then to discuss, how to define the values for the slot offset – which is a bit depending on the discussions on Questions 3.5.2 and 3.5.1, so may not make sense to discuss this yet.

But one additional thing that could be still discussed, is, if we support more than one triggering DCI(i.e. multiple triggering DCIs) for Rel-17 one-shot feedback indicating the same PUCCH slot for the transmission of the PUCCH containing the HARQ-ACK to be re-transmitted as discussed by OPPO. This will have an effect on the HARQ-ACK multiplexing / concatenation discussion later on, i.e. if there is more than one ‘re-transmitted’ HARQ-ACK codebook that may need to be multiplexed / concatenated to the new initial HARQ-ACK CB.

**Question 3.5.3: For Rel-17 one-shot triggering for HARQ-ACK re-transmission:**

* **Alt. 1: Only a single HARQ-ACK codebook / PUCCH occasion can be re-transmitted in a PUCCH slot, i.e. the UE does not expect more than one triggering DCI for Rel-17 one-shot feedback indicating the same PUCCH slot for the re-transmission of HARQ-ACK CBs of different PUCCH slots to be re-transmitted**
  + **Note: i.e. only a single HARQ-ACK codebook / PUCCH occasion can be re-transmitted in a PUCCH slot**
* **Alt. 2: Support more than one triggering DCI for Rel-17 one-shot feedback indicating the same PUCCH slot for the transmission of the PUCCH containing the HARQ-ACK CBs of different PUCCH slots to be re-transmitted**
  + **Note: i.e. more than one HARQ-ACK codebook / PUCCH occasion can be re-transmitted in a PUCCH slot**
* **Alt. 3: other**

|  |  |
| --- | --- |
| Alt. 1 | Nokia/NSB, DOCOMO, vivo, Samsung,OPPO, Sony, Intel, Lenovo/Motorola Mobility, Huawei/Hisi, Panasonic, QC, NEC, CATT, Apple, FGI/APT |
| Alt. 2 | ZTE |
| Alt. 3 |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | Only a single for simplicity. |
| DOCOMO | Alt 1 is simpler and less specification effort is needed. |
| vivo | For simplicity. If multiple codebook needs to be multiplexed into one codebook, triggering Rel-16 Type 3 is easier and sufficient. |
| Samsung | The underlying assumption for the agreement to trigger one CB at a time was that such triggering won’t be typical for multiple CBs (which is essentially what Alt. 2 does but by using different DCIs). Also, no need to (almost unnecessarily) complicate things. |
| Lenovo/Motorola Mobility | If we intend to support retransmission of multiple HARQ-ACK codebooks/PUCCH occasions in one slot, we think one DCI triggering the retransmission of multiple HARQ-ACK codebooks/PUCCH occasions is much more efficient. |
| Huawei/Hisi | As one PUCCH occasion is indicated by per triggering, Alt.1 is more simple and overhead saving. |
| Panasonic | The solution which has simple and less specification effort is preferred. |
| ZTE | The case of more than one HARQ-ACK codebook / PUCCH occasion can be re-transmitted in a PUCCH slot is usual and the will not take huge specification effort, the solution could refer to construction of multiple CBs. |
| QC | Agreement with the arguments above of the supporters of Alt 1. |

* 1. 5th round of email discussions

**5th Round updates: Please note, only the fixed vs. dynamic indication for Type 3 HARQ CB is updated in the 5th round, but please keep commenting on the other remaining issue in the 4th round in Sec. 3.5.**

**Single or multiple enh. Type 3 CBs active at a time (i.e. fixed or dynamic indication):**

As it was commented by some company, that we should not discuss more details if not having something, then let’s continue the proposal from Mr. chairman’s notes, with some minor updates:

* Based on the discussions, it seems clear that if only a single is configured for the UE, there is no impact on DCI size and operation. It has also been discussed, that there may not be a need to increase the DCI size even though more than one enh. Type 3 CB is configured.
* The concern on UE complexity could maybe be handled by defining a UE capability on the maximum number of supported enh. Type 3 CBs at a time. E.g. the UE could report to support {1…X} enh. Type CB, where X is the maximum number supported in the specifications.

So the following update to the proposal in the chairman’s note, is proposed:

**Modified Possible Agreement (for companies to check/discuss via email)**

**For enh. Type 3 HARQ-ACK CB(s) of smaller size,**

* **Support dynamic selection based on indication in the triggering DCI of one of multiple enh. Type 3 HARQ-ACK CB(s) of smaller size.** 
  + **Each of the multiple CBs is at least defined by RRC configuration (FFS based on activation)**
  + **~~At most 2 enh. Type 3 HARQ-ACK CBs of smaller size~~**
  + **This includes UE capability signaling (value range {1…X}) on the maximum number of supported simultaneously configured / active enh. Type 3 HARQ-ACK CBs that can be dynamically indicated**
  + **Details including the value of X are FFS**

|  |  |
| --- | --- |
| Support | [Samsung], DOCOMO, Apple, vivo, OPPO, Spreadtrum, Nokia/NSB,Xiaomi, NEC, Panasonic, Intel, Sharp |
| Object | MediaTek |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | Support the basis of the proposal but capability signalling discussions should be left for UE features. There is no apparent reason for a UE supporting the R16 Type-3 CB to not be able to report a subset of the information from the R16 Type-3 CB. |
| CATT | Although we do not prefer to support dynamic Type 3 HARQ-ACK CBs, we are willing to compromise for the sake of progress.  We have the following comments on the proposal:   1. The existing Type 3 HARQ-ACK CB should be taken into account because it is our understanding that the existing Type 3 HARQ-ACK CB can be configured as one of the multiple Type 3 HARQ-ACK CBs. 2. We do not see the need to FFS CB of smaller size based on activation. 3. We would like to add the case when only one Type 3 HARQ-ACK CB is configured.   **For enh. Type 3 HARQ-ACK CB(s) of smaller size,**   * **Support ~~dynamic selection based on indication in the triggering DCI~~ configuration of one ~~of~~ or multiple Type 3 HARQ-ACK CBs including Rel-16 Type 3 HARQ-ACK CB and enh. Type 3 HARQ-ACK CB(s) of smaller size.**    + **Each ~~of the multiple~~ enh. Type 3 HARQ-ACK CB~~s~~ of smaller size is ~~at least~~ defined by RRC configuration ~~(FFS based on activation)~~**   + **~~At most 2 enh. Type 3 HARQ-ACK CBs of smaller size~~**   + **Support dynamic selection of one configured Type 3 HARQ-ACK CB based on indication in the triggering DCI in case multiple Type 3 HARQ-ACK CBs are configured**   + **This includes UE capability signaling (value range {1…X}) on the maximum number of supported simultaneously configured / active ~~enh.~~ Type 3 HARQ-ACK CBs that can be dynamically indicated**      - **Details including the value of X are FFS** |
| vivo | We prefer moderator’s proposal. |
| Nokia/NSB | About the CATT formulation: it would be good if in the first sentence (main bullet) we cover the essence of what is proposed here (i.e. support the dynamic selection). But better to hear more companies proposals. |
| ZTE | Clarification needed: In the first sub-bullet, there is “FFS based on activation”, does this corresponds the “/ active” in the third bullet? What is the difference between **configured and active?** |
| Sony | Firstly, we do not agree that there is no impact on DCI size if we stop a DL Grant from scheduling PDSCH. Denying a DL Grant from scheduling a PDSCH simply means that ***another DL Grant DCI needs to be transmitted to schedule that PDSCH***. Hence, we would be effectively ***doubling the DCI*** size. This is even worse.  We have similar comments as CATT & ZTE regarding “**FFS based on activation**”. What type of activation are we referring to? Is this an activation DCI e.g. like activating SPS? If we are going with multiple e-Type 3 CB, we would want it to be RRC configured and without this additional dynamic activation. |
| NEC | We prefer moderator’s proposal. |
| Intel | Agree in principle, and indeed ‘FFS based on activation’ may require clarification or removal |
| MediaTek | As mentioned before, we don’t see a need for the dynamic indication of the CB eType-3 CB.  Let’s not forget that we have WA to “*Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16) in Rel-17*”. So, if the companies see eType-3 CB with one size doesn’t actually work, then the WA should be reverted. Legacy Type-3 can be used as it is, and the one-shot HARQ-ACK re-transmission can be used for more optimized operation if needed. |
| Ericsson | * Agree with Samsung, capability disucsison can be handledin UE feature. We suggest to delete that bullet. * Is not clear what these RRC configurations include:   + Do we have Rel-16 as based line and define subsets of cells/HPID and then indicate the set by DCI?   + If that is the intention, the number of sets affects the DCI size.   + Why there is a need to configure many sets? Couldn’t we have baseline as Rel-16 and configure one more set and use 1 bit in DCI to trigger?   + Also not clear what it is meant by activation as others mentioned. |

As there had been the comment we should also check the other way around (i.e. support and objection for Alt. 2), the following proposal is brought forward:

**Proposal 3.6.1: For enh. Type 3 HARQ-ACK CB(s) of smaller size, only a single enh. Type 3 HARQ-ACK CB(s) of smaller size is configured / active at a time**

* + **The CB is at least defined by RRC configuration (FFS based on activation)**
  + **Details are FFS**

|  |  |
| --- | --- |
| Support | DOCOMO, CATT (with update), QC, Sony, Panasonic, Lenovo/Motorola Mobility, MediaTek, Sharp |
| Object | Samsung, vivo, OPPO, Nokia/NSB, ZTE,Xiaomi, NEC |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | That can be up to the Gnb – no need for the specifications to force that ehaviour. |
| DOCOMO | We are fine with either single smaller type 3 HARQ-ACK CB, or selection among multiple smaller type 3 CBs based on dynamic indication. We hope progress can be made on this issue. |
| CATT | It is our preference to support one configured Type 3 HARQ-ACK codebook. It seems that the proposal does not preclude the case that a single enh. Type 3 HARQ-ACK CB and a Rel-16 Type 3 HARQ-ACK CB are configured simultaneously. Our preference is to support only one configured Type 3 HARQ-ACK CB which can be either enh. Type 3 HARQ-ACK CB or the existing Type 3 HARQ-ACK CB.  We propose to update the proposal as follows.  **~~For enh. Type 3 HARQ-ACK CB(s) of smaller size, o~~Only a single Type 3 HARQ-ACK CB (either Rel-16 Type 3 HARQ-ACK CB or enh. Type 3 HARQ-ACK CB~~(~~s~~)~~ of smaller size) is configured / active at a time**   * + **The CB of smaller size is ~~at least~~ defined by RRC configuration ~~(FFS based on activation)~~**   + **Details are FFS** |
| QC | This should be the starting point: definition of a single Enh. Type 3 HARQ-ACK CB   * How the overall size is defined, i.e. it is RRC configured, but having a set of numbers would be useful * How many CCs can be supported? Only activated or configured CCs? * How many HARQ Process per CC? * HARQ Process Numbering across CCs? * How empty HARQ Process entries are going to be filled? * ..   Then, the specification can be extended to more than 1 Enh. Type 3 HARQ CB. The proposal would be   1. Modified Possible Agreement removal 2. Suggestion:   **Modified Proposal 3.6.1: For enh. Type 3 HARQ-ACK CB(s) of smaller size, only a single enh. Type 3 HARQ-ACK CB(s) of smaller size is configured / active at a time**   * + **The CB is at least defined by RRC configuration (FFS based on activation)**   + **Details are FFS**   + **Option to configure a second** **enh. Type 3 HARQ-ACK CB(s) simultaneously is FFS**   A critical question: different activated Enh. Type 3 HARQ CBs differ only in size? Or in other parts as well? |
| Vivo | We share Samsung’s views. |
| OPPO | We share Samsung’s views |
| Nokia/NSB | Agree with Samsung |
| Sony | Similar question regarding the “FFS based on activation”. What is this referring to. |
| NEC | Agree with Samsung |
| MediaTek | If the companies objecting this proposal, then we suggest to revert the WA.  The WA says “*Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16) in Rel-17*”. So, if the companies see eType-3 CB with one size doesn’t actually work, then the WA should be reverted. |
| Ericsson | Usage of active configuration, or activation of configuration at a time, created confusion.  Is the intended operation is that the UE could be configured with multiple sets and DCI indicates which one to choose? If that is the intention, it is beter to clarify that.  Also, some clarity on what it is included in RRC configuration helps to start with:e.g. cell index and HP ID. Then companies can discuss if more parameters are needed to be included in the configuration. |
| QC2 | The proposal is not properly formulated; the question is not on whether the gNB will set a limitation to the UE. The question is whether the UE has to pre-configure a set of different Enh. Type 3 HARQ CB configurations at a given time. By the way, has the group defined   1. What a single Enh. Type 3 HARQ CB configuration will look like? 2. What is going to be the difference between different Enh. Type 3 HARQ CB configurations?   Hence Samsung’s answer to the proposal is not relevant. Unfortunately, this misled other companies.  Updated proposal  **Modified Proposal 3.6.1: For enh. Type 3 HARQ-ACK CB(s) of smaller size, only a single enh. Type 3 HARQ-ACK CB(s) of smaller size is ~~configured /~~ activated at a time**   * + **The CB is at least defined by RRC configuration (FFS based on activation)**   + **Details are FFS**   + **Option to configure a second** **enh. Type 3 HARQ-ACK CB(s) simultaneously is FFS** |

# PUCCH repetition enhancements (at least for HARQ-ACK), e.g., sub-slot based, etc.

In this section, the company positions on the support of PUCCH repetition enhancements (incl. sub-slot type of PUCCH repetition) are summarized. At RAN#90, the following clarification on the focus was done:

***RAN conclusion on IIoT scope:***

* *For handling of the PUCCH repetitions it is proposed to proceed as follows:*

1. *RAN1 to continue discussion on PUCCH repetition, whether to specify or not, in the IIoT/URLLC WI for single TRP.*
   1. *The following items are not within scope of the continued discussions in the IIoT/URLLC WI:*
      1. *DMRS-less PUCCH with UCI payload up to 11 bits*
      2. *PUSCH-repetition-Type-B like PUCCH repetition*
      3. *DMRS bundling across PUCCH repetitions*
2. *PUCCH repetition issues with multi-TRP to be handled in Fe-MIMO WI.*

* *For the UE CSI/HARQ-ACK feedback enhancements in the IIoT/URLLC WI, RAN1 work to continue the discussions. Status to be checked in March if any RAN level guidance needed.*
  + *RAN1 to continue discussion on A-CSI on PUCCH, whether to specify or not.*

The following related agreements were achieved:

|  |
| --- |
| Agreements: Support sub-slot based PUCCH repetition for HARQ-ACK based on the Rel-16 PUCCH procedure for slot-based PUCCH applied to sub-slot based PUCCH   * Note: the intention is to take the Rel-16 slot-based PUCCH by replacing with “sub-slot” appropriately, without further optimization unless necessary * FFS whether or not there is any restriction for the applicability of sub-slot based PUCCH repetition for HARQ-ACK * Dynamic repetition indication is supported also for sub-slot based PUCCH in Rel-17   + FFS: if the method to be specified in Cov. Enh WI for slot-based PUCCH repetition can be directly applied to sub-slot PUCCH or if changes are needed   Agreements: Support PUCCH repetition for PUCCH formats 0 and 2 at least for sub-slot based PUCCH repetition.   * FFS: Support for slot-based PUCCH repetition |

* 1. Summary of companies input in their contributions

**Confirm the Cov. Enh. WI on the repetition factor configuration per PUCCH resource and indication using PRI (2)**: Huawei/HiSi [1], Ericsson [4]

* Seems directly applicable also for URLLC and sub-slot repetition (**7**): Nokia/NSB [3], ZTE [6], CATT [9] (applicable for slot & sub-slot based), Panasonic [10], LGE [18], Intel [21], Xiaomi [27]

‘***nrofSlots*’ also applicable for sub-slot based PUCCH repetition (2):** ZTE [6], Panasonic [10] (if sub-slot PUCCH repetition and dynamic repetition indication are separate features).

**Support slot-based PUCCH repetition for PUCCH Format 0 and Format 2 also for single TRP (6xYes – 2x No):** Huawei/HiSi [1], Nokia/NSB [3], Ericsson [4], Spreadtrum [5], Sharp [24], DoCoMo [26] – **NO, not needed**: ZTE [6], Xiaomi [27]

**Support sub-slot based PUCCH repetition also for other UCI types, including SR and CSI (7 vs 1)**: vivo [2], Nokia/NSB [3] (for Rel-15 RRC configured repetition factor *nrofSlots*), Ericsson [4] (dynamic repetition indication), ZTE [6], Samsung [8], CATT [9] (for dynamic repetition indication), Sharp [24] – **No – only for HARQ:** DoCoMo [26]

**Interaction of RRC configured & dynamic repetition indication:**

* **If dynamic repetition indication is available, ignore *nrofSlots*:** Ericsson [4], ZTE [6]
* **Leave the discussion to the Cov. Enh. WI:** Nokia/NSB [3]
* **FFS if for a PUCCH resource the dynamic repetition factor is not configured (use K=1 or *nrofSlots*):** LGE [18]

**Transient gaps (see discussion by Intel in [21] & RAN4 reply LS [R1-2102297])**

* **Introduce a mechanism of skipping UL symbols during repetitions mapped based on X-symbol gap, Y-sub-slot gap or invalid symbol pattern:** Intel [21]
  + *Moderator question*: This skipping would only be applied if the TX parameters from PUCCH repetition to PUCCH repetition change? Otherwise (i.e. no TPC change, no FH, ..), such skipping would not be applied?

**Other suggested enhancements:**

* Drop a PUCCH repetition overlapping with a high-priority DG PUSCH to prevent high-priority UL-SCH data dropping: Nokia/NSB [3]
* Enable multiplexing of HARQ-ACK & SR (at least for PUCCH of priority index 1) to reduce SR latency: Nokia/NSB [3]
* Reducing the priority of a repetition according to the number of repetitions that have already been transmitted: Sony [7]
* For UCI mapping on PUSCH, scale the number or REs for UCI with the repetition number: Intel [21]
  + *Moderator comment*: Based on the running specs, PUSCH overlapping with a PUCCH repetition occasion is to be dropped (i.e. no UCI multiplexing of a PUCCH on PUSCH) – is the intention to change this behavior as well?
  1. 1st Round of email discussions

Looking at the dynamic repetition indication working assumption from Cov. Enh. WI and the related information provided by companies, it seems that there is consensus between companies that that the working assumption from Cov. Enh. can be directly applied to URLLC and sub-slot based dynamic repetition indication.

**Proposed RAN1 conclusion: The dynamic repetition indication solution for slot-based PUCCH repetition from the RAN1#105-e working assumption from Cov. Enh. WI can be directly applied for dynamic repetition indication for sub-slot based PUCCH repetition.**

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, Sony, Intel, Sharp, ZTE, DOCOMO, Spreadtrum, Qualcomm, ETRI, NEC, CATT, China Telecom, Huawei, Lenovo/Motorola Mobility |
| Objecting companies |  |

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| --- | --- |
| *Company* | *Comments* |
| Samsung | Can wait to first see what the solution is.  Moderator: this conclusion is only about the working assumption. In case a different solution is chosen, we may need to re-discuss. But currently now work needed in 8.3.1.1 – at least this is the intention to take the conclusion. |
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Two companies raised, that not just dynamic repetition indication for sub-slot PUCCH is supported but also semi-static configuration of PUCCH repetition factor using *nrofSlots*. It is the moderator’s understanding that this was the intention in the overall decision when talking about using the slot-based PUCCH repetition framework.

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| --- |
| Agreements: Support sub-slot based PUCCH repetition for HARQ-ACK based on the Rel-16 PUCCH procedure for slot-based PUCCH applied to sub-slot based PUCCH   * Note: the intention is to take the Rel-16 slot-based PUCCH by replacing with “sub-slot” appropriately, without further optimization unless necessary * FFS whether or not there is any restriction for the applicability of sub-slot based PUCCH repetition for HARQ-ACK * Dynamic repetition indication is supported also for sub-slot based PUCCH in Rel-17   + FFS: if the method to be specified in Cov. Enh WI for slot-based PUCCH repetition can be directly applied to sub-slot PUCCH or if changes are needed |

But just to be sure the following is proposed to clarify this and including some decision on the related UE capabilities:

**Proposal 4.1: For sub-slot based PUCCH repetition for HARQ-ACK, semi-static configured PUCCH repetition (i.e. using *nrofSlots*) and dynamic repetition factor based operation is supported.**

* **Sub-slot based PUCCH repetition based on semi-static configuration (i.e. using *nrofSlots*) and based on dynamic indication is subject to separate UE capabilities**

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic. Ericsson, Sony, Intel, Sharp, ZTE, DOCOMO, Samsung, Qualcomm, ETRI, NEC, CATT, China Telecom, FGI/APT, LG, Huawei, Lenovo/Motorola Mobility, Mediatek |
| Objecting companies |  |

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| *Company* | *Comments* |
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Moreover, RAN1 agreed to support of PUCCH repetition for PUCCH format 0 and 2 for sub-slot based PUCCH repetition in general as well as for slot-based PUCCH repetition so far specifically only for M-TRP operation. **6 companies suggest to also support slot-based PUCCH repetition of PUCCH formats 0 and 2 also for S-TRP operation whereas 2 companies see no specific need for it.**

**Proposal 4.2: Support slot-based PUCCH repetition for PUCCH Format 0 and Format 2 also for single TRP operation.**

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, Intel, Sharp, DOCOMO, Qualcomm, ETRI, NEC, CATT, China Telecom, FGI/APT, Huawei, Mediatek |
| Objecting companies |  |

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| *Company* | *Comments* |
| Nokia, NSB | We don’t see a reason why this would be supported only for sub-slot based PUCCH repetition in general as well as for M-TRP and slot-based – but not for S-TRP operation there. |
| Ericsson | We share same view as Nokia. In general, the more exceptions we create, the more fragmentation and usability of a feature. The situations vendors face in real deployments are far more diverse and we shouldn’t make the specifications fragmented at first place, to face shortcoming when a feature becomes needy. |
| ZTE | Originally we don't support this proposal, but we can compromise to major view and be open to support this proposal. |
| Samsung | We generally do not support specifying something for the sake of specifying it when there is no identifiable use case, but would not object to having slot based repetitions for PF0/2. |
| LG | We don’t see the use case to extend support of PF0/2 to slot-based operation. Originally it was inevitable to support PF 0/2 for sub-slot based case. However, that couldn’t be a reason to support slot-based as well. |
| Apple | LG has a point here, maybe the use case can be clarified? |

**Sub-slot based PUCCH repetition for other UCI types:**

We so far only decided to support sub-slot based PUCCH repetition for HARQ-ACK. Several companies discussed in their TDocs the support of sub-slot based PUCCH repetition also for other UCI types, where most companies think some additional UCI could be support also but also some companies also think this is not needed. Moreover, there may be a difference when looking at semi-statically configured PUCCH repetition (i.e. using *nrofSlots*) where the PUCCH repetition factor is actually defined per PUCCH format compared to the case of dynamic repetition indication. To see where the group overall stands on this issue, the following question is brought forward. **Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below.**

**Question 4.1: For sub-slot based PUCCH repetition, in addition to HARQ-ACK (agreed so far) the following UCI types should be support for, adopt the following:**

* **Alt. 1: SR based on semi-statically configured PUCCH repetition (i.e. using *nrofSlots*)**
  + **Supporting companies: Nokia/NSB, OPPO, Panasonic, Sharp, ZTE, CATT, Huawei, Lenovo/Motorola Mobility** …
  + **Companies not supporting: Sony, DOCOMO** …
* **Alt. 2: SR based on dynamic PUCCH repetition indication**
  + **Supporting companies: Nokia/NSB, Sharp, CATT** …
  + **Companies not supporting: Sony, DOCOMO** …
* **Alt. 3: P-CSI based on semi-statically configured PUCCH repetition (i.e. using *nrofSlots*)**
  + **Supporting companies: Nokia/NSB, OPPO, Panasonic, Sharp, ZTE, CATT, Lenovo/Motorola Mobility** …
  + **Companies not supporting: Sony, DOCOMO,** …
* **Alt. 4: P-CSI based on dynamic PUCCH repetition indication**
  + **Supporting companies:** …
  + **Companies not supporting: Nokia/NSB, Sony, DOCOMO** …
* **Alt. 5: SP-CSI based on semi-statically configured PUCCH repetition (i.e. using *nrofSlots*)**
  + **Supporting companies: Nokia/NSB, OPPO, Panasonic, Sharp, ZTE, CATT, Lenovo/Motorola Mobility** …
  + **Companies not supporting: Sony, DOCOMO** …
* **Alt. 6: SP-CSI based on dynamic PUCCH repetition indication**
  + **Supporting companies:** …
  + **Companies not supporting: Nokia/NSB, Sony, DOCOMO** …
* **Alt. 7: Other**
  + **Supporting companies:** …

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| --- | --- |
| *Company* | *Comments or Alt. 7 – other handling* |
| Nokia, NSB | We support SR for both cases (semi-static & dynamic) but don’t see a need to support for sub-slot PUCCH CSI-repetition with dynamic indication (for semi-static this is applicable, as this is PUCCH format specific). |
| OPPO | Alt 1,3,5  It is not clear for us how to dynamically indicate repetition for semi-static PUCCH resource. |
| vivo | SR/P-CSI/SP-CSI are semi-static UCI types, and no DCI indication will be involved, so here dynamic PUCCH repetition indication may cause ambiguity.  We understand the “dynamic PUCCH repetition indication” here means the “PUCCH repetition factor configured per PUCCH resource”. **So, Alt. 1/2/3/4/5/6 can all be supported.** |
| Panasonic | The support of dynamic PUCCH indication for SR, P-CSI, and SP-CSI is under discussion in CovEnh WI. We think the conclusion made by CovEnh WI should be applied to sub-slot-based PUCCH repetition. |
| Sony | Sub-slot based PUCCH was specifically introduced for HARQ-ACK only in Rel-16. Hence it the repetition of sub-slot based PUCCH should be used only for HARQ-ACK. |
| Intel | Overall we are open to support sub-slot based PUCCH repetitions for UCI other than HARQ-ACK for a less fragmented design, but we don’t see the need for semi-static CSI sub-slot repetitions |
| Sharp | We support Alt. 1/2/3/5. The ambiguity mentioned by vivo should be clarified. |
| DOCOMO | We share similar view with Sony and we don’t see strong motivation to support sub-slot based PUCCH repetition for CSI and SR. |
| Samsung | Rel-16 can be trivially extended to include sub-slot repetitions in Rel-17. No other enhancement is needed. May revisit if CovEnh decides otherwise – for now, Alt. 1/3/5/6 are agreeable. |
| Qualcomm | Alt 1 and 2. Difficult to see the case of CSI transmission within a sub-slot. |
| FGI/APT | Alt. 1, Alt. 3, and Alt. 5. |
| LG | We don’t have strong view. However, agreed way is to configure repetition factor to each PUCCH resource so that parameter can be utilized regardless of scheduling method and types of UCI. Thus, all alternatives can be considered. |
| Huawei | Alt.1. The scope of this topic is to enhance the HARQ-ACK for URLLC. SR could also be enhanced regarding to its importance for URLLC, but we do not observe strong motivation for enhancing CSI for URLLC scenarios. |
| Lenovo, Motorola Mobility | For semi-statically configured PUCCH transmissions, PUCCH repetition can also be semi-statically configured. |
| Ericsson | We have same comment as vivo. What is it meant by dynamic indication for semi-statically configured resources? |

**Interaction of RRC configured & dynamic repetition indication:**

The interaction of RRC configured and dynamic repetition indication is discussed. 4 companies provided their input. Let’s try to get some input from more companies on this issue. The moderator would still add here one additional option not discussed by companies, namely that if dynamic repetition factor is not configured at all (i.e. for no PUCCH resource) then the PUCCH configured is applied – otherwise, the dynamic repetition factor applies (also if K=1 is configured or no repetition factor for a resource is configured).  **Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below.**

**Question 4.2: For sub-slot based PUCCH repetition, the interaction of RRC configured PUCCH repetition (i.e. using *nrofSlots*) and dynamic repetition indication the following handling is preferred:**

* **Alt. 1: Leave the discussion to the Cov. Enh. WI and apply the same handling as for slot-based PUCCH repetition**
  + **Supporting companies: Nokia/NSB (1st preference), OPPO (1st preference) , vivo, Panasonic, Sony, Intel, Sharp, ZTE, DOCOMO, Samsung, ETRI, NEC, CATT, China Telecom, FGI/APT, LG, Huawei, Lenovo/Motorola Mobility, Ericsson,** …
* **Alt. 2: If dynamic repetition indication is available, ignore *nrofSlots***
  + **Supporting companies: OPPO (2nd preference), Sharp, ETRI, LG, Ericsson,** …
* **Alt. 3: If K=1 is indicated dynamically or no repetition factor is configured for a PUCCH resource, apply *nrofSlots***
  + **Supporting companies:** …
* **Alt. 4: No interaction – apply either dynamic repetition indication or RRC configured**
  + **If dynamic repetition indicator is configured for any PUCCH resource, apply the dynamic repetition indication (incl. K=1 for PUCCH resources not having a dynamic repetition factor configured). Only if dynamic repetition indication is not configured for any PUCCH resource, the *nrofSlots* is applied**
  + **Supporting companies: Nokia/NSB (2nd preference), Qualcomm** …
* **Alt. 5: Other**
  + **Supporting companies:** …

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| --- | --- |
| *Company* | *Comments or Alt. 5 – other handling* |
| Nokia/NSB | We think we should leave this to the Cov. Enh. WI. If to be decided here for sub-slot based PUCCH, we think Alt. 4 is the cleanest solution (i.e. either semi-static configuration or dynamic indication based on the RRC configuration). |
| OPPO | Either Alt 1 or Alt 2 |
| vivo | Alt.1. One clarification is what does above **K mean?** |
| Sony | We think Cov Enh should handle this to avoid conflicting agreements between Cov Enh WI and IIoT-URLLC WI. |
| Intel | Leave up to CovEnh |
| Sharp | Alt 1 or Alt 2. |
| ZTE | Alt.1 |
| Samsung | Alt. 1 |
| Qualcomm | Alt 4 |
| FGI/APT | Alt.1 |
| LG | Alt. 1 or Alt. 2 |
| Huawei | Alt.1 |
| Ericsson | Alt 1 or Alt 2 |

**Transient gaps (see discussion by Intel in [21] & RAN4 reply LS in R1-2102297)**

Intel raised the issue of transient gaps needed in case there is back-to-back PUCCH repetition of PUCCH with different transmission parameters (such as FH due to different RB allocation and PUCCH TPC / power change) based on RAN4 LS in R1-2102297.

Intel suggesting 3 ways how to define this:

* based on X-symbol gap
* based on a Y-sub-slot gap
* based on an invalid symbol pattern

It is the moderator’s understanding, that a similar discussion on this restriction was carried out in RAN1 already in the context of M-TRP in NR-feMIMO with the following conclusion from RAN1#104bis:

|  |
| --- |
| **Conclusion**  With reference to the normative work on NR-feMIMO:  Related to the support of switching gap between UL transmissions towards two TRPs in RAN1 specifications, there is no consensus in RAN1 to specify symbol gap(s) for the following cases   * PUSCH Type A * PUCCH scheme 1 * PUSCH Type B * PUCCH scheme 3   The above applies for the case included in the LS from RAN4 in R1-2102297. |

Intel raised the issue of transient gaps needed in case there is back-to-back PUCCH repetition of PUCCH with different transmission parameters (such as FH, TPC,..) based on RAN4 LS. **Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below.**

**Question 4.3: For handling transient gaps for 2OS sub-slot PUCCH (see discussion by Intel in [21] & RAN4 reply LS in R1-2102297, adopt the following:**

* **Alt. 1: Handling based on an X-symbol gap**
  + **Supporting companies: Intel** …
* **Alt. 2: Handling based on a Y-sub-slot gap**
  + **Supporting companies: Intel**…
* **Alt. 3: Handling based on an invalid symbol pattern** 
  + **Supporting companies: Intel**…
* **Alt. 4: Follow the (final) operation defined in NR-feMIMO** 
  + **Supporting companies: Nokia/NSB, OPPO, vivo, Sony, ZTE, CATT, LG, Lenovo/Motorola Mobility, Samsung,** …
* **Alt. 5: Other**
  + **Supporting companies:** …

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| --- | --- |
| *Company* | *Comments or Alt. 5 – other handling* |
| OPPO | Alt.4 |
| Intel | Alt.3 > Alt.2 > Alt.1  We still think the motivation for explicit gaps is there based on RAN4 reply LS, and we fail to see why not to handle it.  Our understanding of Alt.4 is no handling. |
| Samsung | The issue dates back to Rel-15 (e.g. intra-slot FH for a PUCCH) particularly for higher SCS – it is not necessarily specific to sub-slots. Can follow the MIMO conclusions. |
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* 1. 1st checkpoint proposals (Aug. 19th)

On being able to use the working assumption on PUCCH repetition from Cov. Enh. all companies indicate the working assumption can be applied.

Therefore, the following conclusion is proposed:

**Proposed RAN1 conclusion: The dynamic repetition indication solution for slot-based PUCCH repetition from the RAN1#105-e working assumption from Cov. Enh. WI can be directly applied for dynamic repetition indication for sub-slot based PUCCH repetition.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, Sony, Intel, Sharp, ZTE, DOCOMO, Spreadtrum, Qualcomm, ETRI, NEC, CATT, China Telecom, Huawei, Lenovo/Motorola Mobility, LG |
| Objecting companies |  |

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| --- | --- |
| *Company* | *Comments* |
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Also all companies agreed to support semi-static *nrofSlots* in the first round. So the following is proposed to be agreed:

**Proposal 4.1: For sub-slot based PUCCH repetition for HARQ-ACK, semi-static configured PUCCH repetition (i.e. using *nrofSlots*) and dynamic repetition factor based operation is supported.**

* **Sub-slot based PUCCH repetition based on semi-static configuration (i.e. using *nrofSlots*) and based on dynamic indication is subject to separate UE capabilities**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic. Ericsson, Sony, Intel, Sharp, ZTE, DOCOMO, Samsung, Qualcomm, ETRI, NEC, CATT, China Telecom, FGI/APT, LG, Huawei, Lenovo/Motorola Mobility |
| Objecting companies |  |

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| *Company* | *Comments* |
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During the first round, the input by companies indicated to support also Proposal 4.2. Three companies indicated that they do not actively support the proposal but would not object either. Therefore, the following is proposed (Round 1 indications included below):

**Proposal 4.2: Support slot-based PUCCH repetition for PUCCH Format 0 and Format 2 also for single TRP operation.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, Intel, Sharp, DOCOMO, Qualcomm, ETRI, NEC, CATT, China Telecom, FGI/APT, Huawei |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| LG | We don’t have strong concern to support repetition of PF0/2. However, we still don’t see the identified use case. |
| ZTE | Now we are open to this proposal, just to keep the spec commonality. I share LG’s view on the use case. |
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* 1. 2nd Round and 3rd Round of email discussions

**Pending proposal from Check-up:**

Apple objected, as they see little use case for it in the check-up. Please note that there are similar discussions also in Cov. Enh. WI on the issue, so there is some use case for it. Maybe to make it easier for Apple to consider the large number of supporting companies, maybe we could make clear that there is a separate UE capability defined (and added as a subbullet). Earlier supporting companies please check if you would be fine with this addition:

**Modified Proposal 4.2: Support slot-based PUCCH repetition for PUCCH Format 0 and Format 2 also for single TRP operation.**

* **The support is subject to independent UE capability indication**

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| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, Intel, Sharp, DOCOMO, Qualcomm, ETRI, NEC, CATT, China Telecom, FGI/APT, Huawei, Spreadtrum, Xiaomi |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| LG | We don’t have strong concern to support repetition of PF0/2. However, we still don’t see the identified use case. |
| ZTE | Now we are open to this proposal, just to keep the spec commonality. I share LG’s view on the use case. |
| Nokia/NSB | Use case may be motivated by Cov. Enh, and agree with ZTE that specs commonality is a big plus. |
| Xiaomi | We can make a compromise to support this proposal |

**Sub-slot based PUCCH repetition for other UCI types:**

Question 4.1 seems to not have been well structured, so better to split the question in two parts, namely what we do with SR and CSI there with the dynamic repetition indication (using the PRI field) – and what we do if the UE is configured for sub-slot PUCCH repetition with nrofSlots (but not with dynamic indication).

**Question 4.1A: For sub-slot based PUCCH repetition configured with / using dynamic indication (using PRI based), the following UCI types are supported:**

* **Alt. 1: HARQ-ACK only**
* **Alt. 2: HARQ-ACK and SR**
* **Alt. 3: HARQ-ACK, SR & CSI (i.e. all UCI types)**
* **Alt. 4: other**

|  |  |
| --- | --- |
| **Companies supporting Alt. 1 – HARQ only** | Samsung, DOCOMO,Xiaomi, LG, Spreadtrum, OPPO, ZTE, Sony, Mediatek |
| **Companies supporting Alt. 2 – SR & HARQ** | QC, CATT (1st preference), Intel, Nokia/NSB |
| **Companies supporting Alt. 3 – HARQ, SR & CSI (i.e. all UCI types)** | CATT (2nd preference), vivo |
| **Companies supporting Alt. 4: other** |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | Should probably skip Q4.1A as a similar discussion occurred in CovEnh – as for the other proposals, can follow CovEnh conclusions. |
| Panasonic | We share the similar view with Samsung. |
| Nokia/NSB | Agree with Samsung, that maybe we could take the agreement from Cov. Enh. WI. |
| Xiaomi | Agree with Samsung |
|  |  |

**Question 4.1B: For sub-slot based PUCCH repetition configured with / using *nrofSlots* (i.e. not using dynamic indication), the following UCI types are supported:**

* **Alt. 1: HARQ-ACK only**
* **Alt. 2: HARQ-ACK and SR**
* **Alt. 3: HARQ-ACK, SR & CSI (i.e. all UCI types)**
* **Alt. 4: other**

|  |  |
| --- | --- |
| **Companies supporting Alt. 1 – HARQ only** | DOCOMO, Xiaomi, Sony |
| **Companies supporting Alt. 2 – SR & HARQ** | Alt 2 |
| **Companies supporting Alt. 3 – HARQ, SR & CSI (i.e. all UCI types)** | Samsung, LG, Spreadtrum, CATT, OPPO, vivo, ZTE, Intel, Panasonic, Nokia/NSB, Lenovo/Motorola Mobility |
| **Companies supporting Alt. 4: other** |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | We do not support any change from Rel-16 other than slot 🡪 sub-slot. |
| Nokia/NSB | Agree with Samsung, Should not be changed from Rel-16 slot-based. |
|  |  |
|  |  |
|  |  |

**Interaction of RRC configured & dynamic repetition indication:**

Looking at the feedback received to Question 4.2, there seems to be a large majority of companies suggesting to leave the discussions to the Cov. Enh. WI. As therefore **any agreement in this AI seems rather improbable, the moderator will not continue discussions on this issue in this RAN1 meeting. If you disagree, please provide your comments below.**

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | OK |
|  |  |
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|  |  |

**Transient gaps (see discussion by Intel in [21] & RAN4 reply LS in R1-2102297)**

Similarly, looking at the feedback received to Question 4.4, there seems to be a large majority of companies suggesting to adopt whatever solution is specified / defined in NR-feMIMO (if something is specified/defined). **Therefore,** **any agreement in this AI seems rather improbable, the moderator will not continue discussions on this issue in this RAN1 meeting. If you disagree, please provide your comments below.**

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | OK. |
| Intel | Suggest that the moderator highlights this issue as an open issue for the next meeting so that companies can think further.  Moderator: will do in the final summary. Hope I will not forget! |
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* 1. 4th and 5th round of email discussions

**5th Round updates: No new proposal or discussions, but please check the reply from DoCoMo on the UCI types when using *nrofslots*! DoCoMo has as point, that if we support the repetition also for SR and CSI, we need to make changes as the reference point for the PUCCH resource for SR and CSI is the start of the slot (and not the sub-slot).**

**Please take that into account, in case you want to change your position with respect to Proposal 4.5.1.**

There had been an earlier objection by Apple, to not support Proposal 4.2. There had been further discussions during 3rd round without any objection, so let’s check if Apple would be willing to compromise.

**Modified Proposal 4.2: Support slot-based PUCCH repetition for PUCCH Format 0 and Format 2 also for single TRP operation.**

* **The support is subject to independent UE capability indication**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, Intel, Sharp, DOCOMO, Qualcomm, ETRI, NEC, CATT, China Telecom, FGI/APT, Huawei, Spreadtrum, Xiaomi, Sony |
| Objecting companies |  |

|  |  |
| --- | --- |
| Apple | Even though we still don’t see the use case for such an operation, we are fine to take it as a compromise. |

On the support of other UCI types for dynamic indication, several companies mentioned we could adopt the same as for slot-based PUCCH based on the Cov. Enh. WI. Therefore, the moderator proposes to halt the related discussions for this meeting, and check next RAN1 meeting again (also considering the progress in Cov. Enh. WI).

On the semi-static configured sub-slot based PUCCH repetition (see question 4.1.B), there seems to be a very large majority of companies proposing to support all UCI types, to align with the operation of slot-based and sub-slot based PUCCH repetition (i.e. no specs change needed).

Therefore, the following is proposed:

**Proposal 4.5.1: To align with Rel-16 slot-based PUCCH repetition operation, sub-slot based PUCCH repetition configured with / using *nrofSlots* (i.e. not using dynamic indication) supports PUCCH repetition of all UCI types (incl. HARQ, SR & CSI).**

|  |  |
| --- | --- |
| Supporting companies | Samsung, LG, Spreadtrum, CATT, OPPO, vivo, ZTE, Intel, Panasonic, Nokia/NSB, Lenovo/Motorola Mobility,Xiaomi, FGI/APT, Sharp, Ericsson |
| Objecting companies | DOCOMO, Sony |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| DOCOMO | We don’t see motivation to support sub-slot PUCCH repetition for CSI and SR. |
| Apple | Support |
| DOCOMO2 | We admit that supporting sub-slot based repetition is beneficial for SR and CSI reliability. But our concern is whether the motivation to improve SR/CSI reliability is so strong if specification change is needed.  I’m not sure whether companies have common understanding on required specification change to support sub-slot based PUCCH repetition for SR and CSI PUCCH. So we want to share our understanding as below.  In current specification, if sub-slot is configured, PUCCH resource for HARQ-ACK is defined based on sub-slot unit, i.e. relative to first symbol of the sub-slot. However, PUCCH resource for other UCI types (i.e. SR, CSI) is defined based on slot unit, i.e. relative to the first symbol of the slot.  *Section 9.2.1 in TS38.213:*  *If a UE is provided subslotLengthForPUCCH in a PUCCH-Config, the first symbol of a PUCCH resource in PUCCH-Config for multiplexing HARQ-ACK in a PUCCH transmission is relative to the first symbol of the subslotLengthForPUCCH symbols [12, TS 38.331]. For the remaining cases, the first symbol of a PUCCH resource is relative to the first symbol of a slot with  symbols [4, TS 38.211].*  Therefore, in our understanding, at least the definition of PUCCH resource for SR and CSI needs to be changed if we want to reuse Rel-16 slot-based framework in section of TS38.213 (as following).    However, if we change definition of PUCCH resource for SR and CSI into sub-slot unit similar to HARQ-ACK resource interpretation, it seems interpretation of periodicity for SR and CSI report configuration also needs to be updated.  That’s why we think we need to be careful to consider the motivation. But if companies all think the benefit of sub-slot based repetition for CSI and SR PUCCH deserve such specification effort, we can be flexible to compromise for progress. |
| vivo | We think to support sub-slot repetition for SR and CSI, it may not be necessary to change the PUCCH resource definition, periodicity for SR and CSI given current spec already defined that  - if the UE is provided subslotLengthForPUCCH in the first PUCCH-Config, the PUCCH resource for any SR configuration with priority index 0 or any CSI report configuration in any PUCCH-Config is within the subslotLengthForPUCCH symbols in the first PUCCH-Config |
| DOCOMO | Thanks vivo for sharing your view. We agree that PUCCH resource for SR and CSI should be confined within a sub-slot. But according to following paragraph, the first symbol of CSI/SR resource is relative to the first symbol of slot:  Section 9.2.1 in TS38.213:  If a UE is provided *subslotLengthForPUCCH* in a *PUCCH-Config*, the first symbol of a PUCCH resource in *PUCCH-Config* for multiplexing HARQ-ACK in a PUCCH transmission is relative to the first symbol of the *subslotLengthForPUCCH* symbols [12, TS 38.331]. For the remaining cases, the first symbol of a PUCCH resource is relative to the first symbol of a slot with  symbols [4, TS 38.211].  For exmple, the “*startingSymbolIndex*=10, and *nrofSymbols*=2” is also confined within a sub-slot.  OR do you have any different understandings on this paragraph? |
| Sony | Sub-slot PUCCH was introduced with only HARQ-ACK in mind. It was never meant for SR and CSI and hence the specs never cater sub-slot PUCCH to carry SR and CSI. We didn’t support sub-slot SR & CSI for dynamically indicated PUCCH and was hesitant to support it for semi-static sub-slot PUCCH repetition. It seemed due to the initial Rel-16 intentions, there may be more than just “covert slot to sub-slot unit” and everything is sorted. Hence, we now share the same view as DOCOMO and do not think we should introduce this. |

# Type 1 HARQ CB based on sub-slot PUCCH config

In this section, the Type 1 HARQ-ACK codebook support for sub-slot based PUCCH configuration is discussed. The following related agreements from previous meetings are available on this topic:

|  |
| --- |
| Agreement: Support Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration in Rel-17.   * The properties of the Type-1 HARQ-ACK codebook for sub-slot PUCCH at least includes that a PDSCH TDRA is associated with a UL /PUCCH sub-slot if the end of the PDSCH overlaps with the associated sub-slot determined by a k1 in the set of sub-slot timing values K1. * FFS: whether the PDSCH TDRA grouping is performed per DL slot or sub-slot   + Decide between PDSCH TDRA grouping per DL slot and sub-slot during RAN1#105-e |

* 1. Summary of companies input in their contributions

**TDRA grouping:**

* **Option 1 (7): TDRA pruning/grouping per DL slot after TDRA determination per UL sub-slot.**
  + **Support:** Huawei/HiSi [1], Nokia/NSB [3], ZTE [6], Samsung [8], CATT [9], OPPO [14] (?), Qualcomm [16] (… TDRA pruning based on the Rel-15 approach)
  + **Arguments**: reduce the CB size (Huawei/HiSi [1], Nokia/NSB [3])
* **Option 2 (4): TDRA pruning/grouping per ‘DL’ sub-slot after TDRA determination per UL sub-slot.**
  + **Support:** Spreadtrum [5], NEC [12], TCL [25], DoCoMo [26]
  + **Arguments**: Grouping per slot results in larger Type 3 CB: Spreadtrum [5], less specs changes: TCL [25], DoCoMo [26]

**Further provided details on the procedure:**

* Huawei/HiSi [1]
  + *Step 1: Determine DL slots consisting of DL sub-slots associated to the determined UL sub-slot*
  + *Step 2: In each determined DL slot, prune the PDSCH SLIVs whose ending symbols overlap with DL sub-slots that not associated to the determined UL sub-slot based on K1 set.*
  + *Step 3: Perform per slot SLIV splitting among the remaining SLIVs for each slot to generate the TDRA groups, each group of which is associated with the HARQ-ACK bit field.*
* Ericsson [4]
  + Support Type-1 HARQ codebook for sub-slot HARQ-ACK by updating the pseudo code for determining a set of occasions for candidate PDSCH reception where the ratio is changed to , where N is the number of sub-slots in an UL slot.
  + Example pseudo code for pruning/grouping per DL slot presented
* Spreadtrum [5]

1. For a UCI to be sent in sub-slot n, determine the union set of K1 values in unit of sub-slot according to the DCI formats the UE is configured to monitor PDCCH.
2. Determine the union set of row indexed of TDRAs for DCI formats the UE is configured to monitor PDCCH
   1. At sub-slot n-K1 with the given value K1, all the PDSCH occasions (end symbols are whining sub-slot n-K1) indicated in the TDRA tables configured by higher layers are considered to determine the codebook size.
   2. If PDCCH starting symbol as the reference of SLIV is supported, the corresponding SLIVs with starting symbol replaced by should also be added into candidate PDSCH occasion sets.
3. The PDSCH occasions that conflict with TDD DL/UL configuration are removed first. The remaining PDSCH occasions selection for determining the codebook size is given as the procedure below:
4. Select T to be smallest end symbol index of all the available SLIVs in sub-slot n-K1.
5. Move the corresponding SLIV with ending symbol T into the chosen SLIV set .
6. Cancel the remaining SLIVs that starts no later than T.
7. Go back to step 1) until all the SLIVs ending in sub-slot n-K1 are looped and get the final SLIV set to generate HARQ-ACK bits.

* ZTE [6]
  + *Determine the DL slot corresponding to the type1 HARQ-ACK codebook;*
  + *Within the determined DL slot, if the end symbol of a PDSCH TDRA does not overlap with the determined UL sub-slot (n-k1), then delete the PDSCH TDRA from the PDSCH TDRA of the determined DL slot;*
  + *The remaining PDSCH TDRA in the determined DL slot is divided into SLIV groups per slot level;*
  + *Generate HARQ-ACK information for each SLIV group.*
* OPPO [14]
  + *Step 1: Determine candidate DL subslots corresponding to one UL subslot based on the K1 set.*
  + *Step 2: If the last symbol of a PDSCH TDRA row r is not in the candidate DL subslots, row r is removed from the candidates of TDRA rows.*
  + *Step 3: Determine occasions for candidate PDSCH receptions based on the remaining PDSCH TDRA rows.*

**Other:**

* Further study the HARQ-ACK location determination for SPS release in the Type-1 HARQ-ACK codebook based on sub-slot PUCCH configuration: NEC [12]
* HARQ-ACK bits will only be present in the semi-static type-1 codebook if the corresponding sub-slot has at least one PDCCH transmission or SPS PDSCH reception: NEC [12]
  1. 1st Round of email discussions

On the Type 1 HARQ-ACK codebook for sub-slot PUCCH, there is a single FFS pending namely if the TDRA grouping/pruning should be done per DL slot or per (UL) sub-slot.

* **7 companies** indicated their support **per DL slot**, as this may lead to a smaller Type 1 HARQ-ACK codebook size
* **4 companies** indicated their support **per (DL) sub-slot**
  + 2 companies raise the point that this may be simpler, but acknowledge the issue of (slightly) larger Type 1 HARQ-ACK CB size.
  + 1 company (Spreadtrum) argues that grouping per slot would lead to larger CB size, which seems to be a different understanding compared to the rest of the companies (and the discussions from RAN1#104bis-e)

As the majority of companies suggesting the grouping per DL slot and there seems to be also the technical merit of a smaller Type 1 CB size, the following is proposed:

**Proposal 5.1: For Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration in Rel-17, the TDRA pruning/grouping is performed per DL slot after TDRA determination per UL sub-slot.**

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia, NSB, OPPO with modification, vivo, Sony, ZTE, DOCOMO, Samsung, Spreadtrum, CATT, China Telecom, Huawei |
| Objecting companies | Qualcomm, LG |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| OPPO | In our understanding, TDRA is determined per DL sub-slot firstly, so we suggest：  **For Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration in Rel-17, the TDRA pruning/grouping is performed per DL slot after TDRA determination per ~~UL~~ DL sub-slot.** |
| Qualcomm | Our proposal was not correctly captured. We support TDRA prunning per sub-slot.  Similar to Spreadtrum’s observations, we also identified cases in which the per slot based prunning lead to larger payload sizes.    Consider the following example. The PUCCH cell is configured with 15 KHz SCS, subslot duration = 2 symbols, and with the set of slot timing offsets K1={2,3,4}. And a DL serving cell is configured with 30 KHz SCS. Suppose that, at UL subslot nU=6, the UE needs to send HARQ-ACK feedback to the gNB. For per-slot based prunning, it will check the DL slots that overlaps with the UL subslots nU-4, nU-3, nU-2.  This yields the DL slot 0 and DL slot 1. For each of the DL slots, the UE shall generate 3 bits HARQ-ACK, since there’re at most 3 non-overlapping PDSCH occasions defined in a DL slot. This yields 6 HARQ-ACK bits in total.  However, for sub-slot based TDRA prunning, the UE will determine 1 bits, 2 bits, and 1 bit for UL subslots nU-4, nU-3, nU-2, respectively. Altogether, this yields 4 bits, which is smaller than the 6 bits required in per-slot based prunning.    Moderator comment:  I guess the QC assumption is incorrect, as first the applicable TDRAs are defined per subslot (please note the discussion from QC during RAN1#104b-e) and only the remaining TDRA entries are then pruned per slot. Meaning, in slot#0, only TDRA 1, 4 and 5 are applicable before the slot-based pruning (resulting in 1bit, as they are all overlapping)) and for slot #1, only TDRA 0, 2 and 3 are applicable (resulting in 2bit) – so in total for the example you get 3 bit with the sub-slot pruning (in contrast to 4bits for the sub-slot – as you pointed out). |
| NEC | Though TDRA pruning/grouping is performed per DL sub-slot is preferred, we can accept this proposal for progress.  In Rel-16, HARQ-ACK location for SPS release in slot based Type-1 CB is based on the SLIV of corresponding SPS PDSCH. For sub-slot based Type-1 CB, in some cases, after TDRA determination per UL sub-slot, the DL slot for PDCCH reception for SPS release may not include the SLIV of the corresponding SPS PDSCH, as shown in the figure below, then the HARQ-ACK location for SPS release cannot be found in the CB. So we suggest to add one FFS:  FFS HARQ-ACK determination for SPS release |
| LG | We support sub-slot based grouping considering design perspective.  We also agree that slot-level grouping could bring less bit size without loss of scheduling possibility. However, since PDSCH-to-HARQ timing is based on length of UL slot, it is more straightforward to use sub-slot based grouping for re-use current specification. Meanwhile, slot-level grouping has benefit up to SLIV table, such as a SLIV spans multiple sub-slot but overlapped with other SLIV in different sub-slot. In our view, we expect considerable specification effort compared to the benefit. |
| Huawei | To QC: per slot based TDRA grouping does not mean to include all the TDRAs in the slot into the codebook (I guess that is why you derive 6 bits in total, i.e., 3 bits for each slot which includes all 6 TDRAs). On the contrary, per slot based TDRA grouping method will prune the unavailable sub-slots from the slot before performing the TDRA grouping. As shown in your figure, regarding the DL part corresponding to UL subslot#2/#3/#4 are available, TDRA 0/2/3 are pruned for DL slot#1, and TDRA 1/4/5 are pruned for DL slot#2. Thus for DL slot #1 the TDRA group is {1,4,5} which results in 1 bit, while for DL slot#2 the TDRA group is {0,2,3} which results in 2 bits – the total payload is reduced to 3 bits. |

In addition to the decision on if the TDRA grouping/pruning is done per DL slot or sub-slot, some companies already provided some details on the way this is then to be captured in 38.213 (either based on suggested steps or directly providing some related TPs).

It is the moderators understanding, that when taking the decision to support Type 1 HARQ-ACK codebook for sub-slot based PUCCH that the time spent on discussing related issues should be minimized. The moderator does not see it as essential to discuss the final structure in 38.213, as this can be left to the 38.213 editor to implement at the end of the release. Therefore, the following is proposed:

**Proposal 5.2: Do not discuss any pseudo-code / TPs on the Type 1 HARQ-ACK codebook construction for sub-slot based PUCCH during the Rel-17 WI phase.**

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, vivo, ZTE, DOCOMO, Samsung, CATT, China Telecom, Huawei |
| Objecting companies | OPPO, Ericsson, Qualcomm, LG |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| OPPO | In our understanding, procedure logic should be discussed firstly and pseudo-code/TP can be provided by editor.  The intention of this proposal is not clear for us. |
| Ericsson | It is understandable that the proposal tries to have the high-level principle established first. However, it seems that companies still have different understanding of the two options and how they are implemented.  It seems having one common example where the application of the two options is explained and understood commonly can be a way forward for the remaining discussion.  Furthermore, we are confused by this proposal. It is Editor responsibility to update the spec. Even if a TP is agreed by the group, Editor has full mandate to make necessary updates to capture in specifications.  If discussing proposals by using TP, facilitates the discussion should not be discouraged. |
| Qualcomm | While we understand that it may not be feasible to discuss every details of the pesudo codes for Type-1 HARQ-ACK CB construction for subslot based PUCCH during the WI phase, we do believe that it is important to agree on the detailed procedures to make sure that all companies have the same understanding about how to implement these procedures, that there is no holes in the agreed procedures, and to make sure that such procedures can be described using the same pesudo code as for the legacy slot-based Type-1 HARQ-ACK CB construction with minimum spec changes.  Otherwise, we might end up in a similar situation as in Rel-16: many companies believed that sub-slot based Type-1 HARQ-ACK CB construction was already supported in Rel-16 during the WI phase, but only to find out the opposite during the CR phase, and there is not enough time left to fix it/implement any new changes.  By the nature of the problem, we think it is hard to agree on all the details of the procedure without discussing the pseudo code (otherwise, we would have described the steps for the codebook construction in the NR Rel-15 spec, instead of including a pseudo code).  Furthermore, we think that the amount of spec changes required by each option should be taken into account when making the decision. Without discussing the pseudo code, it is unclear how this can be compared between the two options under discussion. |
| Moderator | We could discuss if time allows towards the end of the release, but from my perspective if we have sufficient information to define the final Type 1 CB size – we could leave the rest to the editor (e.g. different looping or so, that may just lead to a different order of the bits mapped to the Type 1 CB). At least will not set up any follow-up discussing during RAN1#105-e. |
| LG | We are discussing now how to construct Type-1 CB for sub-slot based PUCCH, thus pseudo code should be final result of our discussion.  We also understands that the discussion would be harsh. Instead, we may be able to discuss few more high-level procedure rather than CR-level text (e.g., order of looping, unit of each lopping). |

Moreover, one companies proposes further enhancements to the Type 1 CB for sub-slot PUCCH (see ‘Other’ in the summary). Also, here it is the moderator’s understanding, when taking the decision on the support the FFS point on additional enhancements had been removed to limit the further work on this feature (and not take time from other HARQ-ACK enhancements of Sec. 2, 3, 4 & 6). Therefore, the following is proposed:

**Proposal 5.3: Do not discuss any further enhancements or optimizations for the Type 1 HARQ-ACK codebook for sub-slot based PUCCH during the Rel-17 WI phase.**

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Sony, ZTE, DOCOMO, Samsung, CATT, China Telecom, Huawei |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
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* 1. 2nd Round and 3rd Round of email discussions

I do not plan to discuss anything more in this meeting on Type 1 CB construction than the needed FFS on slot/sub-slot based grouping, to not distract from other features that require more urgent decisions.

**It seems that some more discussions on the slot or sub-slot based grouping/pruning is needed. Most probably this needs to be taken in one of the GTW sessions for decision. I hereby copy the Round 1 result and for companies to continue during 2nd phase. Maybe e.g. QC could check the replies and re-consider there position and the additional input provided by companies.**

**Further update in Round 3, let’s use only per ‘sub-slot’ in the last part of the sentence. Hope that Samsung could then reconsider its position.**

**Mod2 Proposal 5.1: For Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration in Rel-17, the TDRA pruning/grouping is performed per DL slot after TDRA determination per ~~UL(DL)~~ sub-slot.**

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia, NSB, OPPO with modification, vivo, Sony, ZTE, DOCOMO, Spreadtrum, CATT, China Telecom, Huawei, Samsung,Xiaomi |
| Objecting companies | Qualcomm, LG |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| OPPO | In our understanding, TDRA is determined per DL sub-slot firstly, so we suggest：  **For Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration in Rel-17, the TDRA pruning/grouping is performed per DL slot after TDRA determination per ~~UL~~ DL sub-slot.** |
| Qualcomm | Our proposal was not correctly captured. We support TDRA prunning per sub-slot.  Similar to Spreadtrum’s observations, we also identified cases in which the per slot based prunning lead to larger payload sizes.    Consider the following example. The PUCCH cell is configured with 15 KHz SCS, subslot duration = 2 symbols, and with the set of slot timing offsets K1={2,3,4}. And a DL serving cell is configured with 30 KHz SCS. Suppose that, at UL subslot nU=6, the UE needs to send HARQ-ACK feedback to the gNB. For per-slot based prunning, it will check the DL slots that overlaps with the UL subslots nU-4, nU-3, nU-2.  This yields the DL slot 0 and DL slot 1. For each of the DL slots, the UE shall generate 3 bits HARQ-ACK, since there’re at most 3 non-overlapping PDSCH occasions defined in a DL slot. This yields 6 HARQ-ACK bits in total.  However, for sub-slot based TDRA prunning, the UE will determine 1 bits, 2 bits, and 1 bit for UL subslots nU-4, nU-3, nU-2, respectively. Altogether, this yields 4 bits, which is smaller than the 6 bits required in per-slot based prunning.    Moderator comment:  I guess the QC assumption is incorrect, as first the applicable TDRAs are defined per subslot (please note the discussion from QC during RAN1#104b-e) and only the remaining TDRA entries are then pruned per slot. Meaning, in slot#0, only TDRA 1, 4 and 5 are applicable before the slot-based pruning (resulting in 1bit, as they are all overlapping)) and for slot #1, only TDRA 0, 2 and 3 are applicable (resulting in 2bit) – so in total for the example you get 3 bit with the sub-slot pruning (in contrast to 4bits for the sub-slot – as you pointed out). |
| NEC | Though TDRA pruning/grouping is performed per DL sub-slot is preferred, we can accept this proposal for progress.  In Rel-16, HARQ-ACK location for SPS release in slot based Type-1 CB is based on the SLIV of corresponding SPS PDSCH. For sub-slot based Type-1 CB, in some cases, after TDRA determination per UL sub-slot, the DL slot for PDCCH reception for SPS release may not include the SLIV of the corresponding SPS PDSCH, as shown in the figure below, then the HARQ-ACK location for SPS release cannot be found in the CB. So we suggest to add one FFS:  FFS HARQ-ACK determination for SPS release |
| LG | We support sub-slot based grouping considering design perspective.  We also agree that slot-level grouping could bring less bit size without loss of scheduling possibility. However, since PDSCH-to-HARQ timing is based on length of UL slot, it is more straightforward to use sub-slot based grouping for re-use current specification. Meanwhile, slot-level grouping has benefit up to SLIV table, such as a SLIV spans multiple sub-slot but overlapped with other SLIV in different sub-slot. In our view, we expect considerable specification effort compared to the benefit. |
| Huawei | To QC: per slot based TDRA grouping does not mean to include all the TDRAs in the slot into the codebook (I guess that is why you derive 6 bits in total, i.e., 3 bits for each slot which includes all 6 TDRAs). On the contrary, per slot based TDRA grouping method will prune the unavailable sub-slots from the slot before performing the TDRA grouping. As shown in your figure, regarding the DL part corresponding to UL subslot#2/#3/#4 are available, TDRA 0/2/3 are pruned for DL slot#1, and TDRA 1/4/5 are pruned for DL slot#2. Thus for DL slot #1 the TDRA group is {1,4,5} which results in 1 bit, while for DL slot#2 the TDRA group is {0,2,3} which results in 2 bits – the total payload is reduced to 3 bits. |
| Qualcomm2 | Thanks @Huawei for the explanation. We see that slot-based construction could be further optimized in order to reduce the payload size. However, we are not sure if all companies are on the same page about how slot-based Type-1 HARQ-ACK CB construction was performed (based only on the high-level descriptions from company contributions), and whether they all agree with the approaches suggested by Huawei for the example considered in the figure. It may be great if other companies could comment whether this is the intended behavior for slot-based HARQ-ACK CB construction.  As commented in the previous round, the amount of spec changes required to implement the two approaches should be taken into account before we can make a final decision for down-selection. The sub-slot based construction method is very straightforward, since K1s are measured in subslot, and there’re already a loop in UL subslots /K1 in the current pseudo code. However, it’s very unclear how the procedures for the slot-based construction can be implemented in the pseudo code in TS 38.213 without changing the structure of the code, and how to interact with the mixed numerology logic in the pseudo code. The slot-based construction requires some back and forth between indexing of DL slots and UL subslots, which is not yet in the Rel-16 spec.  Further, as commented by LG, the benefit of slot-based Type-1 construction approach is to have a smaller payload size in some scenarios. However, this is all based on how SLIV is configured by the gNB. In many cases, the gNB can configure SLIV tables such that the two approaches yield the same payload size. As such, we don’t think that the limited benefit above could justify the amount of spec effort required to implement slot-based construction method. |
| Samsung | We support TDRA pruning/grouping is performed per DL slot. We share same understanding with HW that the TDRA associated with unavailable sub-slots is already excluded, according to the agreement in RAN1 104-e-bis  Agreement:  The properties of the Type-1 HARQ-ACK codebook for sub-slot PUCCH at least includes that a PDSCH TDRA is associated with a UL /PUCCH sub-slot if the end of the PDSCH overlaps with the associated sub-slot determined by a k1 in the set of sub-slot timing values K1.  We don’t support “TDRA determination per ~~UL~~(DL) sub-slot”. In our understanding, TDRA determination is done with UL sub-slot by each sub-slot timing values K1. In other words, we firstly identify a UL sub-slot, and then, find the corresponding TDRA set.  In short, we support:  **For Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration in Rel-17, the TDRA pruning/grouping is performed per DL slot after TDRA determination per UL sub-slot.** |
| LG2 | We share similar view to Qualcomm. There is clear trade-off between payload optimization and specification effort.  Slot-level grouping for sub-slot based HARQ-ACK basically means to break existing hierarchy of HARQ-ACK codebook structure. In Rel-16, per K1, a UL slot is considered as a reference of codebook construction. By adopting DL slot grouping, a reference would be a DL slot. What it means is that most of current specification cannot be re-used, in other aspect such as different SCS handling and slot aggregation handling. In this case, we believe that it is not possible just to leave work to editor.  Again, slot-level grouping has benefit up to SLIV table, such as a SLIV spans multiple sub-slot but overlapped with other SLIV in different sub-slot. In our view, we expect that considerable specification effort is required compared to the benefit. |
| Spreadtrum | Previously, we have same view as some other companies such as QC that TDRA pruning/grouping per DL slot means including all the TDRAs in the slot into the codebook if this slot is indicated by one of the K1 values in the set. In this case, using per sub-slot based TDRA grouping has less spec. affect and smaller codebook size.  On the contrary, pruning the PDSCH SLIVs whose ending symbols overlap with DL sub-slots that not associated to the determined UL sub-slot based on K1 set as proposed by Huawei, in our mind, can be seen as an optimization since it is not a standard step in Rel-15, although the complexity is acceptable, but it may has larger spec. affect compared with per sub-slot based TDRA grouping. Overall, we keep open mind to do further discussion. |
| Huawei2 | **To QC**: As analysed in our contribution R1-2106490, the saved payload can be up to 3 bits for per DL slot as shown in the figure below (7bits for subslot based TDRA, vs 4 bits for slot based TDRA), and we would not say the **~43%** saved payload is negligible. Actually we would find the payload saving generally exist in examples with cross sub-slot boundary SLIVs. Regarding we are enhancing the URLLC feature, the saved bit(s) and the resulted smaller payload generally means more robust transmission and better reliability performance.    **To LG**: The R15 TDRA grouping includes 3 steps:   * **Step 1:** For a UL slot where the UE has to transmit HARQ-ACK information, loop the PDSCH-to-HARQ-timing value k1 in timing set K1 to find the candidate DL slots which is associated with the UL slot with respect to k1. * **Step 2:** For each candidate DL slot, prune the SLIVs that is conflict with the UL symbol regarding to the DL/UL configuration from the TDRA table. * **Step 3:** For the rest of the SLIVs, perform the SLIV splitting to generate the TDRA groups, each group of which is associated with the HARQ-ACK bit field.   If per slot based TDRA grouping is adopted in R17, the steps would be changed as below:   * **Step 1:** For a UL subslot where the UE has to transmit HARQ-ACK information, loop the PDSCH-to-HARQ-timing value k1 in timing set K1 to find the candidate **DL slots** including at least one DL subslot which is associated with the UL subslot with respect to k1. * **Step 2:** For each candidate **DL slot**, prune the SLIVs that is conflict with the UL symbol regarding to the DL/UL configuration from the TDRA table, and prune the SLIVs whose ending symbols overlap with the DL sub-slots that are not associated to the determined UL subslot. * **Step 3:** For the rest of the SLIVs, perform the SLIV splitting to generate the TDRA groups (per DL slotlevel), each group of which is associated with the HARQ-ACK bit field.   We can see per slot TDRA grouping will not change the basic principle/logic for the 3 steps of the legacy pseudo-code, and the specification impact within each step is not as huge as the 1st impression. Similar analysis have been found also at the contributions of ZTE, Ericsson, and Nokia. |
| Qualcomm3 | To Huawei, as commented on the 2nd Round, we acknowledge the payload size benefit of slot-based construction. What we are suggesting is to carefully consider the tradeoff between spec impact/UE implementation complexity and the benefit. And whether the benefit is significant enough to justify the amount of spec work/UE implementation complexity required to support slot-based construction.  The example shown in HW’s example shows 43% payload size reduction. However, such configuration is rather a corner case. What is the average benefit, if we consider typical TDRA configurations that UE will see in the field?  Both Qualcomm and LG have raised concerns on the spec impact of slot-based design, given the existing structure of the pesudo code in 38.213. In addition, for UE implementation, slot-based design is also more complicated, due to the need to do a slot-level regrouping after TDRA prunning based on UL subslot. For comparison, the subslot based approach could resuse almost all the Rel-15 implementation (by reintepreting UL slot with UL subslot).  In summary, implementing a more complicated procedure which only has benefit for some corner cases (which is unlikely to be ever configured by a gNB) does not seem to be well justified. |
| Samsung2 | We can support the modified proposal.  We want to emphasise that we previously agreed to support type-1 codebook for sub-slot based PUCCH subject to minimum spec impact. We think the introduction of DL sub-slot has large standard impact, especially for different SCS case. |
| Moderator | As brought up by Apple on the reflector, companies are encouraged to take in their evaluation also the different k=0 interpretation for different UL/DL SCS of slot and sub-slot based operation into account, i.e. the following two proposals to be agreed by email in [106-e-NR-L1enh-URLLC-03] today:  Proposal 1a: For HARQ ACK timing in Rel-16 with sub-slot-based HARQ-ACK feedback, irrespective of UL SCS and DL SCS, k = 0 corresponds to the last UL sub-slot that overlaps with the PDSCH.    Proposal 2: Confirm the RAN1#105-e working assumption with the following modification:  For HARQ-ACK timing in Rel-16 with slot-based HARQ-ACK feedback, in case UL SCS is larger than DL SCS, k = 0 corresponds to the last UL slot that overlaps with the DL slot for the PDSCH.  ~~• Further discuss the HARQ-ACK timing for sub-slot-based HARQ-ACK feedback~~  • FFS specification impact |

* 1. 4th and 5th Round of email discussions

**No 5th round updates, we may just need to make a decision on that one!**

The moderator lack’s inspiration of how to converge here without hard down-selection in a GTW session. But the moderator would not like to spend time in this meeting, as for other issues there are more decisions needed, and some decisions that have an effect on further decisions, whereas for the Type 1 CB for sub-slot PUCCH this is a one-time decision (but no follow-up decisions needed necessarily).

There had been good discussions earlier, and please also note the argument brought up by Apple by email, not sure if this is changing companies’ minds.

|  |
| --- |
| On **Type-1 HARQ-ACK codebook construction for sub-slot-based feedback**, I see that quite some companies are discussing the potential spec impact and arguing that sub-slot-based pruning would result in less spec impact.  This would not be the case if we agree to the following two proposals in [106-e-NR-L1enh-URLLC-03], because the HARQ-ACK timing interpretation would be different for slot-based and sub-slot-based HARQ-ACK timing.  We think we may need to make substantial change to the pseudo code no matter which option we take. We encourage companies to take this into consideration in the further discussion.  Proposal 1a:  **For HARQ ACK timing in Rel-16 with sub-slot-based HARQ-ACK feedback, irrespective of UL SCS and DL SCS, k = 0 corresponds to the last UL sub-slot that overlaps with the PDSCH.**    Proposal 2:  **Confirm the RAN1#105-e working assumption with the following modification:**  **For HARQ-ACK timing in Rel-16 with slot-based HARQ-ACK feedback, in case UL SCS is larger than DL SCS, k = 0 corresponds to the last UL slot that overlaps with the DL slot for the PDSCH.**  **~~·       Further discuss the HARQ-ACK timing for sub-slot-based HARQ-ACK feedback~~**  **·       FFS specification impact** |

So please, take the earlier input into account and let’s check another time here, if companies changed their mind based on the discussions in the previous rounds and the insights by Apple above:

**Mod2 Proposal 5.1: For Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration in Rel-17, the TDRA pruning/grouping is performed per DL slot after TDRA determination per ~~UL(DL)~~ sub-slot.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, DOCOMO, vivo, Samsung,Xiaomi,OPPO, Sony, Huawei/Hisi, Apple, ZTE, CATT, TCL |
| Objecting companies | LG, Qualcomm |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| vivo | If either option require substantial change to the pseudo code. We still support the one generating smaller codebook size. |
| LG | In the current specification, the pseudo code doesn’t care which UL slot is mapped to k=0. The slot , which is corresponding to k=0, is considered static and predefine value in terms of pseudo code.  If those proposals in Apple’s email have effect on pseudo code for grouping for DL slots, it could be one additional reason not to support the proposal. |
| Apple | During the R15/R16 CR discussion, it was identified that if k=0 corresponds to the UL slot that overlaps with the end of PDSCH, the pseudo code for Type-1 HARQ-ACK codebook construction does not always work when the UL SCS is larger than the DL SCS. This was why it was agreed to change the HARQ-ACK timing determination to be based on the end of the DL slot, not the PDSCH itself. Sub-slot-based HARQ-ACK is very similar to the mixed numerology case. The exact issue is explained in more detail in R1-2106301.  We think the pseudo-code would require some non-trivial changes either way for sub-slot-based HARQ-ACK. |
| ZTE | Proposal 1a and 2 will not affect the issue related to proposal 5.1, and proposal 1a itself matches the previous meeting agreement in this Rel-17 topic as Samsung mentioned in the discussion of Rel-16 email reflector. |
| Spreadtrum | We are fine to do further discussion to get good trade-offs between UCI payload and spec. affect. |
| Qualcomm | We do not see why the proposals (now agreements) from Rel-16 URLLC will complicate the Type-1 HARQ-ACK CB construction with sub-slot based PDSCH grouping. Moreover, Proposal 1a above is just a restatement of what’s been agreed in Rel-17 URLLC:  Agreement:  The properties of the Type-1 HARQ-ACK codebook for sub-slot PUCCH at least includes that a PDSCH TDRA is associated with a UL /PUCCH sub-slot if the end of the PDSCH overlaps with the associated sub-slot determined by a k1 in the set of sub-slot timing values K1. |
| NEC | Mixed numerologies should be taken into account when comparing the specific impact betweenTDRA pruning per DL slot and TDRA pruning per DL sub-slot. |
| Apple | Our point is that the current pseudo-code only works well if we assume “k = 0 corresponds to the last UL slot that overlaps with the DL slot for the PDSCH”. It has some issues if we assume “k = 0 corresponds to the last UL slot that overlaps with the PDSCH”. Since for sub-slot we agreed that “k = 0 corresponds to the last UL sub-slot that overlaps with the PDSCH”, some changes are needed for the pseudo-code if we want it to to work well. This is independent of whether we do pruning per DL slot or per sub-slot.  In short, even if we go with per-sub-slot pruning, there is still some additional changes needed for the pseudo code. |

# PUCCH carrier switching for HARQ feedback

In this section, PUCCH carrier switching (at least) for HARQ-ACK feedback is discussed. The following related agreements from previous meetings are available on this topic:

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| --- |
| Agreements: In the studies on PUCCH carrier switching for HARQ-ACK, PUCCH carrier switching for different cells operated is considered only for cells that are part of the active UL CA configuration.  Agreements: **For further study on** **whether and how to support** **PUCCH carrier switching** **in a PUCCH group, focus on the following three alternatives:**   * **Alt. 1: PUCCH carrier switching is based dynamic indication in DCI** * **Alt. 2B: PUCCH carrier switching is based on certain (semi-static) rules** * **Alt. 2C: PUCCH carrier switching is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells** * Note: In above alternatives, it is assumed that HARQ-ACK corresponding to PDSCH received on a Pcell/PScell or an Scell in a PUCCH group, can be sent on a PUCCH onan Scellalso instead ofonly onPcell/PScell/PUCCH-SCellin the same PUCCH group, as opposed to Rel-16 where HARQ-ACK corresponding to PDSCH received on a Pcell/PScell or an Scell in a PUCCH group can only be sent on Pcell/PScell/PUCCH-SCell in the same PUCCH group.   ***Note: Realistic deployment scenarios including TDD configurations should be considered for the study***  Agreement: Support PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH and semi-static configuration   * Details are FFS (including applicability of dynamic and/or semi-static means) * Aim for minimum specification impact * Dynamic indication and/or semi-static configuration are subject to separate UE capabilities * The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells and supports PUCCH carrier switching across cells with different numerologies.   + FFS whether additional rules are needed to support PUCCH carrier switching across cells with different numerologies * FFS the maximum number of PUCCH cells * FFS whether and how to support joint operation of dynamic and semi-static carrier switching for a UE * FFS whether and how to support joint operation of PUCCH carrier switching and SPS HARQ-ACK deferral   Agreement: For PUCCH carrier switching, the PUCCH resource configuration is per UL BWP (i.e. per candidate cell and UL BWP of that specific candidate cell).  Agreement: For PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH (i.e. Alt. 1), the PDSCH to HARQ-ACK offset k1 is interpreted based on the numerology of the dynamically indicated target PUCCH cell. |

* 1. Summary of companies input in their contributions

**Generic for PUCCH carrier switching:**

**Interaction with SPS HARQ-ACK deferral:**

* **Support:** Huawei/HiSi [1], Ericsson [4], CATT [9], NEC [12] (for dynamic indication)
* **Not support:** OPPO [14], ETRI [19]
* **Details:**
  + UE checks validity on the associated target carrier based on the PUCCH carrier switching pattern: Huawei/HiSi [1] – **No:** First apply deferral on PCell and then apply PUCCH carrier switching pattern: Panasonic [10]
  + Perform PUCCH carrier switching first and then check the SPS HARQ-ACK deferral on the target PUCCH carrier: Ericsson [4], CATT [9], NEC [12] (?)
    - ‘slot\_offset’ pattern configured can be used also for SPS deferral: Ericsson [4]
  + Stop the SPS HARQ-ACK deferral search stops as soon as dynamic indication of PUCCH carrier switching is received: Qualcomm [16]

**Limitation on maximum number of PUCCH cells within a PUCCH cell group:**

* 2 (PCell & 1 SCell, 1+1): Samsung [8], CATT [9], OPPO [14], Apple [23]
* 4 (in total, 3+1): Nokia/NSB [3]
* RRC configurable: FGI/APT [15], ETRI [19]
* No limitation needed: FGI/APT [15]

**List of candidate cells:**

* Based on a configured set of candidate carries (using carrier indexing) per cell group: Huawei/HiSi [1], Nokia/NSB [3]

**TPC operation for PUCCH cells:**

* Support separate TPC loops per PUCCH cell: Nokia/NSB [3], Qualcomm [16]
* Support separate P0 / TPC configuration per PUCCH cell: Qualcomm [16], Mediatek [20]
* Support individual TPC command starting points within DCI format 2\_2 for each PUCCH candidate: Nokia/NSB [3]
* Support accumulating closed loop power control commands only within the same target cell by reusing Rel-15 procedure: Qualcomm [16], Nokia/NSB [3], Mediatek [20]
  + For dynamic indication, the TPC command in the DCI scheduling the PUCCH only applies for the dynamically indicated PUCCH target cell: Nokia/NSB [3]
  + For semi-static / time-domain pattern, the TPC command in the DCI scheduling the PUCCH only applies for the determined PUCCH target (using the time-domain pattern): Nokia/NSB [3]

**PUCCH spatial relation update:**

* Support to use MAC-CE to signal PUCCH spatial relation on Scell(s) with PUCCH carrier switch: Qualcomm [16]

**Other:**

* Dynamic and semi-static PUCCH carrier switching should be configured and enabled for dynamic scheduling and SPS separately: Panasonic [10]
* Study and decide if /how to support joint operation of PUCCH carrier switch, parallel PUCCH/PUSCH transmission, and intra-UE multiplexing: Qualcomm [16]
* Support for scheduled PUCCH: Mediatek [20]

**PUCCH carrier switching based on dynamic indication:**

**Carrier indication:**

* Based on a configured set of candidate carries (using carrier indexing) per cell group: Huawei/HiSi [1], Nokia/NSB [3] (list can also be used for semi-static switching / time-domain pattern), Ericsson [4] (‘subset’?)
* **Introduce a new field in the DCI scheduling PDSCH (e.g. DCI formats 1\_1 & 1\_2) (9):** Huawei/HiSi [1], vivo [2], Nokia/NSB [3], Ericsson [4], Samsung [8], LGE [18], Mediatek [20], DoCoMo [26], CAICT [29]
  + Bit-field size can be individually configured for DCI formats 1\_1 & 1\_2: Nokia/NSB [3] – No, size determined by the largest PUCCH carrier set across all PUCCH groups: Ericsson [4][
  + Applicable to DG PDSCH, SPS PDSCH, SPS Release and triggered PUCCH for Type 3 CB: Ericsson [4] – **No:** for SPS dynamic carrier indication is not applicable (ignore in the activation DCI): LGE [18], DoCoMo [26]
  + For DCI format 1\_0, 1bit from HPN or RV field could be used: Samsung [8]
* **PRI is used to instruct PUCCH carrier switching** (**4**) from a new configured PUCCH resource set, which can include PUCCH resources of different UL CCs: ZTE [6], Panasonic [10], LGE [18], Intel [21]
  + PRI field size can be extended: Panasonic [10], Intel [21] – No / questionable: LGE [18]

**Multiplexing of DG HARQ (with dynamic indication), SPS-HARQ, SR and CSI**

* **Multiplex at least HARQ-ACK from PCell / PScell on the dynamically indicated target PUCCH cell if PUCCH slot or PUCCH resource on PCell/PScell overlap with dynamically indicated PUCCH slot or PUCCH resource on the target cell (7):** vivo [2], Nokia/NSB [3], Ericsson [4], CATT [9], NEC [12], DoCoMo [26], CAICT [29]
  + **Alt. 1 PUCCH resources should be overlapping:** Nokia/NSB [3], NEC [12]
  + **Alt. 2 PUCCH slots overlapping, PUCCH resources do not need to be overlapping:** vivo [2], CATT [9], DoCoMo [26], CAICT [29]
  + **Additional details:**
    - Alternatively, a different PUCCH cell(s) may be configured / indicated: vivo [2]
    - Exception is SPS-HARQ together with CSI: Ericsson [4]
    - For mixed SCS, the smallest SCS can be used as the reference slot to determine the overlapping slots CATT [9]
* **HARQ-ACK transmission configured or scheduled for more than one Pcell PUCCH slot overlapping with the indicated PUCCH on Scell (e.g. for mixed SCS)** 
  + is considered as an error case: Nokia/NSB [3]
  + multiplex both SPS HARQ to Scell PUCCH: DoCoMo
* **Pcell PUCCH with HARQ-ACK overlapping with Scell PUCCHs in multiple Scell slots (e.g. of higher SCS)** 
  + is considered as an error case: Nokia/NSB [3]
  + multiplex on the first overlapping Scell slot: DoCoMo [26]
* **Limited to SR and SPS-HARQ only (no CSI):** Nokia/NSB [3], Intel [21] – support also CSI: Ericsson [4]
* **UE does not expect overlapping PUCCHs with dynamic indication on more than one carrier:** Ericsson [4], Interdigital [22], DoCoMo [26]
* **When a slot of a first cell overlaps with one or more slots of a second cell, a UE does not expect to transmit PUCCH in both the slot of the first cell and in any of the one or more slots of the second cell:** Samsung [8]

**HARQ codebook construction:**

* Apply the K1 set configured of the indicated carrier: Huawei/HiSi [1]
* HARQ-ACKs with same priority index pointed to the same slot/sub-slot on the same carrier will be constructed as one codebook: Huawei/HiSi [1]
* For Type 1 CB, the UE is not expected to be configured with non-aligned PUCCH slots and different k1 sets across all PUCCH candidate cells: Nokia/NSB [3] – FFS Type 1 CB construction: NEC [12]
* For Type 2 CB, the Rel-16 mechanism for HARQ-ACK codebook construction can be re-used: Nokia/NSB [3]
* Append HARQ-ACK codebooks on other cells to the original Type 1 or Type 2 CB on the dynamically indicated PUCCH carrier / PUCCH slot: DoCoMo [26]

**Out-of-order issues:**

* OoO rule between the carriers with PDSCH transmission and the carrier with PUCCH transmission should be applied based on the largest SCS: Huawei/HiSi [1]
* Out-of-order HARQ-ACK remains forbidden for non-mTRP scenarios with PUCCH carrier switching: Apple [23], Xiaomi [27]
* Out-of-order triggering is not supported: Xiaomi [27]

**K1 enhancements:**

* Configure additional k1 slot offset (for larger SCS cells): Panasonic [10]

**Other:**

* Guarantee by configuration, that the bit-width of PRI and PDSCH-to-HARQ\_feedback timing indicator is not ambiguous depending on the target cell: China Telecom [11]
* Support for configured SPS HARQ-ACK PUCCH: Mediatek [20]
* Nested PUCCH symbols across CCs are not allowed for PUCCH carrier switching: Apple [23]
* PUCCH switching for SPS HARQ-ACK is achieved by dynamic PUSCH scheduling in another cell: CAICT [29]

**PUCCH carrier switching based on semi-static configuration / time-domain pattern:**

**Reference numerology / cell:**

* **PCell / PSCell / PUCCH-SCell is reference cell (defining granularity of timing pattern and K1 interpretation) (6):** Huawei/HiSi [1], Nokia/NSB [3], Ericsson [4], Qualcomm [16], CMCC [17] (?), DoCoMo [26]
  + PCell/PScell defines the reference slot, slot number of Scells is calculated according to *slot offset configuration given by* : CMCC [17]
* **Reference numerology configured by RRC (2):** vivo [2] (and SCS\_ref needs to be ≤ any SCS of any configured UL bandwidth part), Mediatek [20]
* **Reference carrier configured by RRC (also used for K1 Interpretation) (1):** ZTE [6]
* **Reference numerology is the smaller/smallest SCS (2):** Samsung [8], CATT [9], China Telecom [11], CAICT [29] (of all BWPs)
* **Reference numerology is the largest SCS (1):** NEC [12]

**K1 & PRI interpretation and semi-static PUCCH resource usage:**

* **K1 interpretation on the reference cell to define the PUCCH target cell (7):** Huawei/HiSi [1], Nokia/NSB [3], Ericsson [4], ZTE [6], Samsung [8], China Telecom [11] (PCell, reference numerology for pattern could be different), LGE [19] (PCell/SPCell)
* **PRI interpretation on the PUCCH target cell (5):** Nokia/NSB [3], ZTE [6], CATT [9], LGE [18], Apple [23] (?)
* **Semi-static PUCCH resource on target cell defined by PUCCH-config for the target cell:** CATT [9]

**Configuration details:**

* **Time-domain pattern configured per PUCCH cell group** (**3**): vivo [2], Nokia/NSB [3], Ericsson [4]
* **Individual K1 set configuration per PUCCH cell (1)**: vivo [2]
* **Based on a configured set of candidate carries (using carrier indexing) per cell group (2)**: Nokia/NSB [3] (list can also be used for dynamic indication), Ericsson [4] – use serving cell indexes directly: CMCC [17]
* **Time-domain pattern granularity is one slot of the reference cell / numerology using carrier indexing** (**6**): Nokia/NSB [3] (pattern length up to *maxNrofSlots*), Ericsson [4], NEC [12], CMCC [17] (pattern length of the Pcell/PScell), Mediatek [20], DoCoMo [26] (based on TDD configuration length)
* **Time domain pattern per PUCCH candidate carrier, bitmap length given by number of UL slots within the period** (**1**): ZTE [6]
* gNB to guarantee that the PUCCH carrier switching points are aligned with the PUCCH slot/subslot boundaries: Nokia/NSB [3], CATT [9]
* Time-domain pattern is based on a periodicity and a time duration (for it’s repetition): FGI/APT [15]
* More than one time-domain can be configured and indicated to be applied (allowing for faster switching between patterns): FGI/APT [15]

**Mixed numerology handling:**

* For shorter PUCCH slot length on the target PUCCH cell (than the reference cell / numerology), the PUCCH transmission is in
  + the first PUCCH slot on the target cell overlapping with the PCell slot: Huawei/HiSi [1], Samsung [8], CATT [9], China Telecom [11], Qualcomm [16] (first ‘actual’slot), LGE [18] (first UL slot), DoCoMo [26]
  + using k1\_relative within the PCell slot indicated using HARQ-feedback indicator in the DCI: Nokia/NSB [3]
  + configured slot\_offset pattern to define which overlapping PUCCH slot: Ericsson [4] (i.e. time domain pattern contains ‘cell index’ & ‘slot\_offset’)
  + configured slot-offset per PUCCH target cell (within overlapping PCell slot): Panasonic [10]
* For switching to longer PUCCH slot length on the target cell compared to PCell:
  + gNB implementation takes care of that timelines are met for PUCCH transmission switching to Scell: Nokia/NSB [3]
  + UE does not expect to be indicated for HARQ-ACK codebooks in more than one of the PCell slots overlapping with a single Scell slot configured for PUCCH transmission: Nokia/NSB [3], CATT [9] – **No -** multiplexing should be considered: China Telecom [11], DoCoMo [26] (needs to be clarified if allowed)
* Predefined rules on the PUCCH target cell selection: vivo [2]
  + *Moderator comment*: If one cell is a reference cell in terms of time-domain pattern and K1 interpretation, there should not be any ambiguity on the PUCCH target cell – only for the mixed SCS case (more than one target PUCCH cell slot overlapping with a single PUCCH slot of the reference cell, some further handling needs to be discussed)!??
* No additional rules are needed for mixed SCS / different PUCCH slot lengths: OPPO [14]
* Same SCS operation should be given highest priority: Xiaomi [27]

**PUCCH repetition operation:**

* The target cell is determined for each PUCCH repetition individually: Huawei/HiSi [1]
* Further study: NEC [12], Qualcomm [16], ETRI [19]

**PUCCH carrier switching for SR and CSI:**

* **At least for SR:** vivo [2], Nokia/NSB [3]
* **For any PUCCH (incl. CSI):** Ericsson [4], Samsung [8], ETRI [19]

**HARQ-ACK codebook construction:**

* Type 1 CB uses the K1 set(s) configured for the reference cell / numerology: Nokia/NSB [3], CAICT [29]

**SFI utilization:**

* **Legacy semi-static SFI and dynamic SFI operation applies on the target PUCCH cell:** Apple [23]

**Other:**

* UE selects the PUCCH carrier based on the carrier index in case more than one PUCCH carrier are available: Interdigital [22]
  + *Moderator question*: How could it happen that more than one PUCCH carrier would be indicated for a specific? Anyhow, wouldn’t it be better (if such cases really happen) to define a rule (so that the UE behavior is defined) or expect that gNB configuration would prevent such cases??

**Joint operation of dynamic indication and semi-static configuration:**

**General support for joint operation:**

* **Yes:** Huawei / HiSi [1], Ericsson [4] (incl. RRC state ‘dynamic & SS’), CATT [9], NEC [12] (slightly preferred)
* **No:** OPPO [14]
* **FFS:** Nokia/NSB [3] (first define the details of stand-alone operation)

**Details:**

* If the carrier is dynamically indicated, the dynamic indication applies. If the carrier cannot be dynamically indicated (e.g. using fallback DCI format 1\_0), the semi-static carrier switching applies: Huawei / HiSi [1], Nokia/NSB [3] (from principle point of view), Ericsson [4], Samsung [8], FGI/APT [15] (?)
* Conclude if dynamic PUCCH overriding is allowed if the UCI can be transmitted based on the RRC-based indication: Samsung [8]
* UE does not expect that the dynamically indicated target PUCCH cell is different from the PUCCH cell determined by switching pattern: CATT [9]
* Dedicated indication in DCI for switching between two schemes: Panasonic [10]
* The semi-static carrier switching is applied when the PUCCH transmission is not possible over the dynamic indicated carrier: Panasonic [10]
  1. 1st Round of Email discussions

The following agreement was made during the 1st GTW session:

|  |
| --- |
| **Agreement**  Update the following RAN1#105-e agreement as:   * RAN1#105-e Agreement: For PUCCH carrier switching, the PUCCH ~~resource~~ configuration (i.e. *pucch-Config / PUCCH-ConfigurationList*) is per UL BWP (i.e. per candidate cell and UL BWP of that specific candidate cell).   + FFS: CSI and SR |

**Generic for PUCCH carrier switching**

**Limitation on maximum number of PUCCH cells within a PUCCH cell group:**

In their TDocs, 4 companies indicated the support for a maximum of 2 PUCCH cells within PUCCH cell group, 1 company indicated a maximum of 4 PUCCH cells and 2 companies indicated, that the maximum number of cells should be RRC configurable.

The intention of the maximum number of cells is to enable the RRC signaling & PHYdesign to be able to accommodate the max. number of cells. Of course, even though e.g. the feature design would have a limitation of X cells by RRC configuration there could be a smaller number of cells Y<X configured for the PUCCH carrier switching operation.

Therefore, the moderator thinks that some limit which is not just RRC configurable will be needed to for the feature design. **Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below.**

**Question 6.1: Do you agree with the moderator assessment, that for the design e.g. for RRC signaling a fixed maximum limit on the maximum number X of PUCCH cells per cell group will be needed?**

* ***Note:* The gNB can of course based on RRC configuration configure a smaller number of PUCCH cells Y<X~~<Y~~.**
* **Supporting companies: Nokia/NSB, OPPO, Ericsson, Panasonic, Sony, Intel, ZTE, DOCOMO, ETRI, CATT, China Telecom, Huawei** …
* **Companies not supporting: QC, Samsung, FGI/APT,** …

|  |  |
| --- | --- |
| *Company* | *Comments* |
| OPPO | Support |
| vivo | There is a typo, i.e. X<Y should be Y < X. A fixed maximum limit on the maximum number X may be beneficial for other related designs, we are open to discuss this. |
| Ericsson | Support.  Confirm Typo identified by vivo. |
| Intel | Support generic signalling design |
| ZTE | Support vivo’s revision. |
| DOCOMO | Support correction by vivo. |
| Samsung | The proposal is unnecessary. X=2, fixed in Rel-17. |
| Spreadtrum | Support correction by vivo. |
| QC | This is a minor issue. But our view on this issue is that the procedure should follow 2 steps. Step 1 is UE report capability on the max # cells it can support PUCCH carrier switch. Step 2 is gNB then configuring a list of cells that PUCCH carrier switch is enabled on them. We don’t see the need gNB need to configure max # cells because the list itself implicitly delivers that information. |
| FGI/APT | We share the same view with QC. |
| Huawei | Support. To be more specific, the gNB can configure a set of carriers for switching, and the number of this set could imply Y. |
| Lenovo/Motorola Mobility | We don’t need an agreement on this. This is just a typical way of designing RRC signalling. |

**Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below.**

**Question 6.2: If a fixed maximum limit on the maximum number X of PUCCH cells per cell group is defined:**

* **Alt. 1: X=2**
  + **Supporting companies: Sony, ZTE (second preference), QC, CATT** …
* **Alt. 2: X=4**
  + **Supporting companies: Nokia/NSB, Panasonic, ZTE, Huawei, Lenovo/Motorola Mobility** …
* **Alt. 3: X=? / Other**
  + **Supporting companies:** …

|  |  |
| --- | --- |
| *Company* | *Comments or Alt. 3 – X=? / other* |
| Nokia, NSB | As discussed in our contribution, 4 cells should be sufficient but 2 cells seems to be too limiting. |
| Vivo | We slightly prefer Alt.1. |
| Ericsson | Instead of agreeing now to number of X, we should focus to establish a solid framework for PUCCH carrier switching which is scalable.  Then for UE capabilities, definitely, minimum capability would be with X=2 and more capable Ues may support X>2. |
| Intel | This is a UE capability discussion topic |
| ZTE | Alt.2. Also fine with Alt.1 as second preference. |
| Samsung | Alt. 1. No need for anything other than X=2.  There are no band combinations requiring X>2. We cannot agree to obviously unnecessary complications to specifications particularly given the “aim for minimum specification complexity”. |
| Spreadtrum | Alt.1 or Alt.2. |
| QC | We think 2 cells should be able to harvest most of the switching gain, just like diversity factor 2 harvest most of the diversity gain. But again, we think there is no strong need to define this max #, it can be handled by UE capability reporting. |
| FGI/APT | If a fixed maximum number X is agreed, we prefer to set X as a UE capability and more than just one value (i.e., X can be 2, 4 or other value). Simply set the limit X = 2 is too restrictive to improve the insufficient UL resource issue. |
| LG | Alt. 1 or alt. 2 |
| Huawei | Alt.2. Considering the diversified spectrum bands owned by operators, 4 carriers would be enough to range from low band to high band including FR2. |

**TPC operation for PUCCH cells:**

3 companies raised the issue of independent TPC / TPC loops and suggested to operate independent TPC loops per PUCCH cell. This may include:

* Separate P0 / TPC configuration per PUCCH cell
  + Note: This flexibility is already provided as *PUCCH-config* is per UL BWP of a PUCCH cell (see related discussions there)
* Accumulating closed loop power control commands only within the same target cell by reusing Rel-15 procedure
  + For dynamic PUCC cell indication, the TPC command in the DCI scheduling the PUCCH only applies for the dynamically indicated PUCCH target cell
  + For semi-static / time-domain pattern, the TPC command in the DCI scheduling the PUCCH only applies for the determined PUCCH target (using the time-domain pattern)
* Support separate TPC command indication using DCI format 2\_2 for the individual PUCCH cells (i.e. requiring configuration of individual TPC command starting points for each PUCCH cell within DCI format 2\_2)

**Please add your companies name directly to each of the separate points there , and provide your additional comments or alternatives in the table below.**

**Proposal 6.1: Support independent TPC per PUCCH cell including**

**• Separate P0 / TPC configuration per PUCCH cell**

* + Note: This flexibility is already provided as PUCCH-config is per UL BWP of a PUCCH cell
* **Accumulating closed loop power control commands only within the same target cell by reusing Rel-15 procedure, i.e.** 
  + For dynamic PUCCH cell indication, the TPC command in the DCI scheduling the PUCCH only applies for the dynamically indicated PUCCH target cell
  + For semi-static / time-domain pattern, the TPC command in the DCI scheduling the PUCCH only applies for the determined PUCCH target (using the time-domain pattern)
  + **Supporting companies: Nokia/NSB, vivo, Panasonic, ZTE, DOCOMO, NEC, QC, CATT, LG, Huawei**…
  + **Companies not supporting:** …
* **Separate TPC command indication using DCI format 2\_2 for the individual PUCCH cells**
  + Note: this requires configuration of individual TPC command starting points for each PUCCH cell within DCI format 2\_2
  + **Supporting companies: Nokia/NSB, vivo, Panasonic, ZTE, DOCOMO, NEC, CATT**…
  + **Companies not supporting:** …

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Ericsson | Although we are in general Ok, but we think it is better to have a clearer picture how PUCCH carrier switching is performed and then discuss these details. Of course, during the course of specifying the procedure, we should be mindful on TPC aspects.  Therefore, instead of having a proposal to support an approach, we should integrate the issue of TPC handling as the design progresses.  Moderator comment: PUCCH TPC is a stand-alone issue (independent of mapping etc.), so a bit puzzled about the comment here. |
| Samsung | Similar to PUCCH-SCell having its own PC configurations. The SCell is effectively a “PUCCH-SCell” for a same CG and corresponding specs can be re-used. |
| QC | Regarding this bullet “**Separate TPC command indication using DCI format 2\_2 for the individual PUCCH cells**”. We don’t object it. But we feel it is premature to agree on this particular solution before checking if there are other solutions. Maybe replace the bullet by “FFS power control with DCI format 2\_2 for PUCCH carrier switch” is better at this stage. |
|  |  |
|  |  |

**Dynamic PUCCH cell indication**

**Target PUCCH cell indication**

On the **dynamic PUCCH carrier indication, 9 companies** indicated to include a **new, dedicated field in the DCI** to indicate the target PUCCH carrier, whereas **4 companies** suggest to **use the existing PRI field**, by having a mapping of a combination of target PUCCH carrier and PUCCH resource indication on the target PUCCH carrier to be indicated by the PRI field. Clearly, using PRI and having some need to have a combination of PUCCH resource index and PUCCH cell will complicate the RRC signaling design. As mentioned by some companies, having **a dedicated field will simplify the design**. Therefore, the following is proposed:

**Proposal 6.2: For PUCCH carrier switching based on dynamic indication in the DCI, introduce a new, dedicated DCI field for the DCI scheduling PDSCH to indicate the target PUCCH cell.**

* ***FFS: Bit-field width for DCI format 1\_1***
* **DCI field presence for DCI format 1\_2 is independently RRC configured**
  + ***FFS: Bit-field width for DCI format 1\_2***
* ***FFS: If some bit(s) from existing bit fields could be used for DCI format 1\_0***

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Ericsson (only main bullet), DOCOMO, Samsung, Spreadtrum, QC, NEC, CATT, FGI/APT, Huawei, Lenovo/Motorola Mobility |
| Objecting companies | Intel |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | Support, and as discussed in our contribution the bit-field width could be RRC configured for DCI format 1\_1 and 1\_2 (individually). |
| Panasonic | Our preference is to use to use existing PRI field. We agree to have dedicated field will simplify the design. On the other hand, it may imply PUCCH configuration of the source cell is used to the target cell. If dedicated field means PUCCH configuration of the target carrier PUCCH configuration is used, we are ok to have the compromise it. |
| Ericsson | We agree in principle. But we don’t agree on the FFS.  When the field is configured, the size can be based on RRC configured PUCCH cells (X in other proposals). Also, having different sizes for different DCI formats makes the operation complicated. It makes the benefit of PUCCH carrier switching DCI format dependent which is a strange approach in our view. |
| Intel | We think that PRI space for the PCell/PSCell takes into account different UCI multiplexing scenarios etc. When the same PRI space is used for PUCCH carrying HARQ-ACK on another carrier, it is evidently redundant. To optimize the DCI overhead, PRI could encode both PUCCH resource and target carrier. |
| ZTE | Similar with Panasonic & Intel, our choice is to use the existing PRI field as no more additional overhead in DCI. |
| Samsung | 1 bit field (X=2) – the FFS for the field size can be removed. |
| FGI/APT | The DCI field width can be configurable depending on the number of candidate PUCCH cells in the PUCCH cell group. |
| LG | Similar to Intel’s view. Using PRI would be beneficial to keep DCI size and for odd number of PUCCH cells. |
| Huawei | As a clarification, the PRI field is configured per PUCCH-config. The PUCCH resource sets for PRI are not available until a specific carrier index is obtained. |

In the discussion by different companies, there are different views e.g. for SPS PDSCH if the dynamic PUCCH carrier indication applies or not. Therefore, the following question is brought forward to get feedback from different companies on the applicability of the dynamic cell indication. **Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below.**

**Question 6.3: In addition to HARQ-Ack of PDSCH dynamically scheduled by a DCI indicating a PUCCH carrier, the dynamic target carrier indication also applies to:**

* **Alt. 1: applicable also to SPS PDSCH HARQ-ACK without associated DCI based on the indication in the activation DCI**
  + **Supporting companies: vivo, Ericsson, Intel, ZTE, ETRI, LG,** …
  + **Companies not supporting: Nokia/NSB, DOCOMO, NEC,QC, CATT, Samsung,** …
* **Alt. 2: applicable also to HARQ-ACK of the SPS Activation based on the indication in the activation DCI**
  + **Supporting companies: Nokia/NSB, OPPO, vivo, Panasonic, ZTE, DOCOMO, Spreadtrum, NEC,QC, CATT, FGI/APT,** …
  + **Companies not supporting:** …
* **Alt. 3: applicable also to HARQ-ACK SPS Release based on the indication in the release DCI**
  + **Supporting companies: Nokia/NSB, OPPO, vivo, ZTE, DOCOMO, Spreadtrum, NEC,QC, CATT, Huawei, Lenovo/Motorola Mobility, FGI/APT,**  …
  + **Companies not supporting:** …
* **Alt. 4: applicable also to triggered PUCCH for Rel-16 Type 3 CB, Rel-17 enh. Type 3 CB of smaller size and Rel-17 one-shot triggering for HARQ-Ack retransmission based on the indication in the triggering DCI**
  + **Supporting companies: Nokia/NSB,OPPO, vivo, Intel, ZTE, DOCOMO, ETRI, Spreadtrum, NEC, QC, CATT, Huawei, Lenovo/Motorola Mobility, FGI/APT,**
  + **Companies not supporting:** …
* **Alt. 5: applicable also for SP-CSI based on the dynamic indication in the activation DCI**
  + **Supporting companies:** …
  + **Companies not supporting: Nokia/NSB, DOCOMO, Samsung,** …
* **Alt. 6: ~~Other~~ applicable also for the SCell dormancy indication based on the dynamic indication in the triggering DCI.**
  + **Supporting companies: ZTE**…

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| *Company* | *Comments or Alt. 6 / other* |
| Nokia/NSB | We support any HARQ-ACK in response to a DL assignment indicating the target carrier dynamically (i.e. Alt. 2, 3 and 4) – but think that it should not apply based on some activation command then semi-statically. |
| OPPO | The same view as Nokia/NSB |
| vivo | For Alt.1, as we agreed that the PUCCH resource configuration is per UL BWP and the PDSCH to HARQ-ACK offset k1 is interpreted based on the numerology of the dynamically indicated target PUCCH cell, we did not see the benefits for applying different operation for the first SPS PDSCH after activation and the following SPS PDSCH without the activation DCI.  Regarding Alt.5, SP-CSI on PUCCH is activated/de-activated by respective MAC CE. So no activation DCI is involved in our opinion. |
| Ericsson | Alt 1.  In general, it can be applied to all alternatives including Alt.1 as long as there is a DCI scheduling/activating the transmissions. There is no need to have a restriction. In principle, the indication of PUCCH carrier in the activation DCI simply indicates which PUCCH carrier to use for all SPS HARQ-ACK. This does not incur any additional complexity.  Additionally, all these restrictions increase the specification impact to implement all the exceptions, and eventually UE complexity and NW operation. We should be after simple and clean solution to minimize the spec impact and get something useful form the feature. |
| ZTE | One more case could be considered: the Scell dormancy indication |
| DOCOMO | Share similar view with Nokia. |
| Samsung | The above are not alternatives – they are different scenarios.  For the first and fifth ones, the RRC configuration pattern applies as the transmissions are RRC configured transmissions (that happen to be activated by DCI – but that is irrelevant, could have been RRC or MAC CE). If there is no pattern, Rel-16 applies. |
| Spreadtrum | Share similar view with Nokia. |
| NEC | Share similar view with Nokia. |
| FGI/APT | We support Alt.2, Alt.3, and Alt.4. |
| LG | We support Alt. 1. Similar to Ericsson’s, PUCCH carrier switching can be performed with SPS HARQ-ACK as long as DCI with carrier indication is received for that slot. Considering HARQ-ACK codebook construction, it would be reasonable to think that PUCCH carrier switching is performed per HARQ-ACK codebook. SPS HARQ-ACK information should be taken into account. |
| Huawei | Alt.3/4. Could FL clarify what is the difference between Alt1 and Alt2? They look both the SPS PDSCHs.  Moderator: Alt. 1 is for each SPS PDSCH without associated DCI (i.e. the indicated carrier in the activation command is applied for all SPS PDSCH of that SPS configuration, also for SPS PDSCH without DCI). Alt. 2, this is only the first SPS PDSCH, that is basically scheduled by the activation DCI. I hope this clarifies. |
| Lenovo/Motorola Mobility | Alt 3 and Alt 4. Dynamic PUCCH carrier indication is enabled for HARQ-ACK transmission in response to DCI (e.g. type 3 CB triggering, SPS release indication, SCell dormancy indication). |

3 companies mention, that the dynamic PUCCH cell indication should not be changed for a certain PUCCH slot – i.e. the gNB should always indicate the same PUCCH cell. The following proposal is brought forward:

**Proposal 6.3: UE does not expect overlapping PUCCHs with dynamic PUCCH cell indication on more than one carrier, i.e. gNB should only dynamically indicate a single PUCCH cell for a final PUCCH slot.**

* + **Supporting companies: OPPO, vivo, Panasonic, ZTE, DOCOMO, Spreadtrum, QC,NEC, CATT,** **China Telecom, Huawei, Ericsson,** …
  + **Companies not supporting:** …

|  |  |
| --- | --- |
| *Company* | *Comments* |
| OPPO | Support |
| Ericsson | .~~Not support.~~ -> Support.  ~~Please see previous comment.~~  Moderator comment: Bit puzzled here, as E/// had the following proposal that to the moderator understanding is exactly proposing that. Could you please clarify:  *Proposal 11: The UE does not expect to be indicated with HARQ-ACK transmission in PUCCHs overlapping in different PUCCH carriers.*  Apologies for confusion. Thanks for catching it up. Human errors 😊 |
| DOCOMO | HARQ-ACK CB determination would be complicated if there is overlapping of dynamic HARQ-ACK on different target PUCCH cells. |
| Samsung | Allowing mixtures can create several problems, is not motivated from the reason to introduce the carrier switching (resource unavailability on PCell), and is not consistent with the “aim for minimum spec impact”. |
| Spreadtrum | Support |

**HARQ-ACK multiplexing between PCell/SPCell and target cell (incl. other UCI types)**

**Seven companies discuss the multiplexing for HARQ-ACK on PCell/PSCell** (e.g. for PDSCH scheduled by DCI format 1\_0) and that there should be multiplexing with the HARQ-ACK on the indicated PUCCH cell. **Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below.**

**Question 6.4: For PUCCH carrier switching based on dynamic indication in the DCI, multiplex at least HARQ-ACK from PCell / PScell on the dynamically indicated target PUCCH cell**

* **Alt. 1: if PUCCH slot on PCell/PScell overlaps with dynamically indicated PUCCH slot on the target cell** 
  + **Supporting companies: vivo, ZTE（only for HARQ-ACK）, DOCOMO, CATT, China Telecom**…
* **Alt. 2: if** **PUCCH resource on PCell/PScell overlaps with the dynamically indicated PUCCH resource on the target cell**
  + **Supporting companies: Nokia/NSB, OPPO, Panasonic, ZTE (if including UCI other than HARQ-ACK ),**…
* **Alt. 3: other rules for HARQ-ACK**
  + **Supporting companies: QC, Huawei** …
* ***FFS: for other UCI types (i.e. SR & CSI)***

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| --- | --- |
| *Company* | *Comments or Alt. 3 / other* |
| OPPO | Alt 2 |
| vivo | Alt.1 follows the legacy HARQ-ACK multiplexing/overriding behaviour. |
| Ericsson | **We disagree with the way the proposal is formulated. In our view it is wrong and different aspects are mixed up.**  If target cell is indicated, only that cell and its corresponding numerology should be considered in relation with PDSCH. In other words the target cell would be like PCell/PScell in Rel-15/16. There is no need to detour from PCell/PScell.  Therefore, the problem we have to solve is **how to determine the slot on the target cell that would carry PUCCH based on indicated K1 and indicated target cell in a DCI.**  When that is done, the PRI in DCI, would determine the PUCCH resource that should be used.  Moderator reply: Please note, that there is the mixed SCS handling. How to deal if the SPS HARQ-ACK (having no dynamic indication) where the PCell/PSCell is having a 15kHz SCS (k1 used on PCell) and the target cell is having higher SCS, there is more than one slot overlapping. Any suggestion to have a formulation that would also capture this case (without the need to refer to PCEll/PSCell)  I think Moderate misunderstands our comment. The way the proposal is formulated, it implies that somehow PUCCH carrier switching is not applied for PCell/PScell.  If the intention is that there are UCI in PUCCHs that wont be affected by dynamic PUCCH carrier switching (DL SPS HARQ-ACK, CSI, SR, ..), then it is better to update **HARQ-ACK from PCell / PScell** and clarify clearly that scenario. |
| ZTE | For the HARQ-ACK only, we support Alt.1. For the UCI other than HARQ-ACK, we support Alt.2. |
| DOCOMO | We understand the question is talking about multiplexing for HARQ-ACK on indicated cell and HARQ-ACK on PCell/PScell. In Rel-16, HARQ-ACK multiplexing is based on overlapping of HARQ-ACK reporting slot. It’s better to follow similar principle here. |
| Samsung | Alt. 1 and generally agree with the comments from E///.  We cannot support a UE to have PUCCH transmissions on different cells in overlapping slots. |
| QC | On this issue, to simplify spec impact and UE implementation complexity, we suggest take the same solution as for Proposal 6.3, i.e., gNB scheduler should avoid such overlapping. Otherwise, a cross CC PUCCH on PUCCH multiplexing procedure needs to be defined. Considering different numerologies of different CCs, the PUCCH multiplexing procedure will be super complicated. We admit this will introduce certain scheduling restriction to gNB. But considering the spec work and remaining TUs, it may be unrealistic to introduce cross CC PUCCH on PUCCH multiplexing. |
| NEC | Alt.2. It should follow the legacy multiplexing rule that when two PUCCH resources are overlapped in time domain, UCIs on two PUCCH resource should be multiplexed and transmitted on a PUCCH resource. |
| FGI/APT | We support Alt.1. |
| LG | Support Alt. 2. |
| Huawei | Alt.3. Same view with QC that such scheduling should be avoided. For other semi-static UCIs like SR/CSI, it should be FFS. |
| Lenovo/Motorola Mobility | Legacy HARQ-ACK multiplexing/overriding (by a last DCI) should be kept for PUCCH carrier switching. That is, a PUCCH carrier for HARQ-ACK for a given slot is determined based on the last DCI. |

There had been slightly different opinions, if in addition to HARQ-ACK from PCell/PSCell also CSI and/or SR could be multiplexed on the dynamically indicated SCell. **Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below.**

**Question 6.5: For dynamic PUCCH carrier indication, in addition to HARQ-Ack from PCell/PSCell, the following UCI types are supported to be multiplexed on the indicated PUCCH cell:**

* **Alt. 1: SR**
  + **Supporting companies: Nokia/NSB, OPPO, vivo, Panasonic, ZTE, DOCOMO, NEC, Huawei** …
  + **Companies not supporting: QC, CATT ,** …
* **Alt. 2: P-CSI / SP-CSI**
  + **Supporting companies: OPPO, ZTE, DOCOMO, Huawei,**…
  + **Companies not supporting: Nokia/NSB,QC, CATT** …
* **Alt. 3: Other**
  + **Supporting companies: QC**…

|  |  |
| --- | --- |
| *Company* | *Comments or Alt. 3 / other* |
| Nokia, NSB | Super SR (for latency), but don’t see a need to dynamically move CSI to an alternative carrier. Motivation is HARQ latency, so it should not be an issue to find a valid slot for CSI on the PCell for CSI. |
| OPPO | Alt 1 and 2. |
| Ericsson | One comment as before: **HARQ-Ack from PCell/PSCell** is not correct.  With correction below, we support both Alt-1 and Alt-2. We suggest change Alt-3 as following. It is not clear why an Alt with all of them is excluded.  This proposal overlaps with 6.3 to some extent and discussion before.  **For dynamic PUCCH carrier indication, in addition to HARQ-Ack ~~from PCell/PSCell~~, the following UCI types are supported to be multiplexed on the indicated PUCCH cell:**   * **Alt. 3: SR, P-CSI, SP-CSI, HARQ-ACK for DL SPS…** |
| DOCOMO | We don’t see any specification effort for support of multiplexing SR and P-CSI/SP-CSI on HARQ-ACK on dynamically indicated target cell. If multiplexing is not supported, and if there is overlapping between SR/CSI PUCCH on PCell/PScell and HARQ-ACK PUCCH on dynamically indicated target cell, should UE drop the SR/CSI or transmit PUCCHs on two cells simultaneously?  In our understanding, support of multiplexing SR/CSI from PCell is simpler from specification effort perspective. |
| Samsung | There is no reason to exclude P/SP-CSI and there are several reasons to not exclude it, ranging from performance (including for URLLC) to specification simplicity.  Also agree with the formulation from E/// and support Alt. 3. |
| QC | Similar comment as for Question 6.4, gNB scheduler should avoid such overlapping scenario. |
| LG | Alt. 1. In addition, we would like to point out that multiplexing SPS HARQ-ACK bit is far easier than SR or SP-CSI. |
| Huawei | The semi-static UCI including SR and semi-static CSI should be multiplexed on the dynamically indicated carrier. |
| Lenovo/Motorola Mobility | Legacy multi-UCI multiplexing/dropping rules should be applied to PUCCH carrier switching. |

**Semi-static PUCCH cell indication**

**Pattern definition**

On the **time-domain pattern for semi-static PUCCH switching** the following can be noted:

* **6 companies describe that a single time-domain pattern is configured**, where for each of the slots in the pattern the applicable PUCCH cell is indicated (using either cell ID or some carrier indexing of list of configured candidate carriers) – **whereas one company suggests a time domain pattern for each PUCCH cell**, where the time-pattern for each PUCCH cell is only a bit map of the UL slots within the pattern periodicity (i.e. UE would need to check several patterns to identify the target cell, gNB to prevent by configuration overlaps of the patterns).
* **3 companies** mentioned that the time-domain pattern should be **configured per PUCCH cell group**
* **3 companies** mention that the time-domain pattern length / periodicity, should be **aligned with TDD configuration (i.e. length of 10ms / 1 frame)**
* There are overall different opinions on the reference numerology or reference cell for the time domain pattern. Therefore, this would need to be decided separately.

Based on these observations the following is proposed. **Please add your companies name directly to each of the separate points there , and provide your additional comments or alternatives in the table below.**

**Proposal 6.4: For semi-static PUCCH carrier switching, the time-domain pattern configuration is based on the following properties:**

* **A single time-domain pattern is configured per PUCCH cell group**
  + **Supporting companies: Nokia/NSB, vivo, Panasonic, ZTE, DOCOMO, QC, NEC, CATT, China Telecom, Huawei, Lenovo/Motorola Mobility** …
  + **Companies not supporting:** …
* **The granularity of the time-domain pattern is one slot of the reference numerology / reference cell**
  + ***FFS definition of reference numerology / reference cell***
  + **Supporting companies: Nokia/NSB, vivo, Panasonic, ZTE, DOCOMO, QC, NEC, CATT, China Telecom, Huawei, Lenovo/Motorola Mobility**
  + **Companies not supporting:** …
* **The length of the time-domain pattern is one frame (i.e. 10ms)**
  + **Supporting companies: Nokia/NSB, Panasonic, ZTE, DOCOMO, QC, Huawei,**…
  + **Companies not supporting:** …
* **The pattern defines for each slot of the reference numerology / reference cell the applicable PUCCH cell**
  + ***FFS: if the indication in the time-domain pattern is directly using the serving cell index of the target PUCCH cell or if some additional list of PUCCH cells is configured (which could be used)***
  + **Supporting companies: Nokia/NSB, vivo, Panasonic, ZTE, DOCOMO, QC, NEC, CATT, China Telecom, Huawei**…
  + **Companies not supporting:** …

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | Fully support the proposal.  As also indicated in some other questions, we think we need a reference cell (and not just numerology) and the PCell could be a good choice for that. |
| OPPO | Fine with the proposal except the length of time domain pattern. To avoid collision with DL-UL configuration, the length of the time-domain pattern should be aligned with period of DL-UL configuration.  Moderator comment: having a periodicity of 10ms, allows the gNB to emulate shorter periodicities by having the indication repeated within the 10ms (as also Samsung pointed out). So this should not place any restrictions. Moreover, the pattern may not just be used for TDD collision issues but may moreover be used for load-balancing between UEs. |
| Vivo | Regarding the length of the time domain pattern, it can be up to Gnb configuration, however some limitations may be introduced, for example, it can be integer multiple of the length of TDD pattern.  Besides, for the description “The pattern defines for each slot of the reference numerology / reference cell the applicable PUCCH cell” in the above proposal, it should be clarified that one and only one applicable PUCCH cell can be indicated for each slot of the reference numerology / reference cell. |
| Ericsson | Support.  I think TDD configurations would fit in a frame, but maybe it s good to be cautious. The main point is that the pattern would be applied periodically. Maybe, we can use the following:   * **The ~~length of the~~ time-domain pattern is applied periodically ~~one frame (i.e. 10ms)~~**   + FFS on period (e.g. 10ms, or Period is RRC configured). |
| ZTE | The length of time domain pattern depends on the length of TDD configuration period. Considering 10ms covers the length of TDD configuration period, we can accept the length of the time-domain pattern is one frame. |
| Samsung | OK to keep the length of the pattern FFS although 10 msec should work with any UL-DL config.  A “reference numerology/reference cell” do not need to be defined. The only thing needed is to determine whether the slots corresponding to the time pattern are the ones of the cell with the larger/smaller SCS or of the Pcell. The smaller SCS (active BWP) is preferred as that would lead to the least spec impact and is sufficient. Also OK to use the SCS of the Pcell if it is understood that there will not be support in Rel-17 for the Pcell to have larger SCS than the PUCCH Scell.  We do not support a situation where the pattern is defined for the larger SCS of the two cells. |
| QC | We agree that Pcell could be a good choice for reference cell, because many Rel-15 procedures can be simplify reused with Pcell. |
| NEC | Agree with Ericsson to keep FFS for the length of the time-domain pattern. |
| China Telecom | The length/period of the time-domain pattern can be configurable. The aim is to make it aligned with period of TDD DL-UL configuration. |
| FGI/APT | The period of timing pattern should be configurable and consider the periodicity of TDD configuration of the target PUCCH cell. |
| LG | Fine with the proposal. |
| Huawei | Support in principle. In addition, we share the same view with Ericsson that the specific value of the period can be determined after the basic principle of the semi-static carrier switching is completed. |

**K1 and PRI interpretation**

**On the k1 and PRI interpretation for semi-static PUCCH carrier switching:** Moreover, several companies mention the k1 value should be interpreted on the PCell or a reference cell to define the slot on the PCell/PSCell or reference cell which is then used together with the time-domain pattern (which may or may not have a different reference SCS as the PCell/PSCell or reference cell) to determine the target PUCCH cell. Moreover, a group of companies also mention that the PRI should be interpreted on the determined target PUCCH cell.

**Proposal 6.5: For semi-static PUCCH carrier switching, the PDSCH to HARQ-ACK offset k1 is interpreted based on the numerology and PUCCH configuration of a reference cell to be able to apply the time-domain PUCCH carrier switching pattern.**

* + ***FFS definition reference cell***

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, ZTE, DOCOMO, QC, NEC, CATT, China Telecom, FGI/APT, LG, Huawei, Samsung |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | Also the TPC command and the PRI – no need to single out k1. The whole *PUCCH-Config* is the one for the active BWP of the applicable cell.  Moderator: I do agree, but maybe we take one by one (all of them proposed by moderator, as you may have recognized) |
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**Proposal 6.6: For semi-static PUCCH carrier switching, the PUCCH resource indicator (PRI) is interpreted based on the PUCCH configuration of determined target PUCCH cell.**

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, ZTE, DOCOMO, QC, NEC, CATT, China Telecom, FGI/APT, LG, Huawei, Lenovo/Motorola Mobility, Samsung |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | Also the TPC command and the k1 – no need to single out PRI. The whole *PUCCH-Config* is the one for the active BWP of the applicable cell.  Moderator: I do agree, but maybe we take one by one (all of them proposed by moderator, as you may have recognized) |
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**PUCCH carrier switching operation alternatives:**

There had been different interpretations of how to determine the PUCCH cell using the configured time-domain pattern and the k1 value:

* **Alt. 1:** **Only a reference cell is defined:** The numerology of the reference cell is used to interpret the time-domain pattern for PUCCH cell switching and the reference cell is used to interpret the PDSCH to HARQ-ACK offset k1
  + With this approach, the UE after determining the PUCCH slot on the reference cell using k1 directly can look-up in the time-domain pattern to determine the PUCCH cell in a second step
    - See e.g. Huawei/HiSi [1] assuming the PCell as reference cell
  + The reference cell could be the PCell/PSCell or some RRC configured PUCCH cell (incl. potential configuration restrictions having the smallest or largest SCS of the PUCCH cells)
* **Alt. 2: A reference numerology and a reference cell (of potentially different numerology) is defined:** The reference numerology is used to interpret the time-domain pattern for PUCCH carrier switching, whereas the reference cell (e.g. the PCell/PSCell) is used to interpret the PDSCH to HARQ-ACK offset k1
  + With this approach, the UE first determines the PUCCH slot on the reference cell (e**.**g. PCell/PSCell). In a second step, the UE determines the overlapping slot of the reference numerology with the PUCCH slot on the reference cell. In a third step, the UE determines the PUCCH cell based on the time-domain pattern and the overlapping slot of the reference numerology
    - See, e.g. description by China Telecom [11]

**Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below.**

**Question 6.6: The semi-static PUCCH carrier switching should be based on:**

* **Alt. 1: a reference cell used for the time-domain pattern and k1 interpretation**
  + **Supporting companies: Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, ZTE, DOCOMO, NEC, CATT, Huawei** …
* **Alt. 2: a reference numerology used for the time-domain pattern interpretation and a reference cell is used for the PDSCH to HARQ-ACK offset k1 interpretation**
  + **Supporting companies: China Telecom**…
* **Alt. 3: other**
  + **Supporting companies:** …

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| *Company* | *Comments or Alt. 3 / other* |
| Nokia/NSB | We don’t see any advantage to define some reference numerology, as this will just complicate the operation. Having a reference cell (preferably the PCell) seems to be better suited. |
| OPPO | Alt 1 |
| Ericsson | Alt 1 |
| Samsung | Alt.1 is flawed. The time domain pattern has to be based on slots (i.e. an SCS) – that defines time, ‘cell’ does not define time. Whether the slot/SCS is the one of the PCell is a separate issue. Once the SCS is defined, everything is defined. |
| QC | We don’t have a strong view here. Either approach could work. One point is that, either with Alt 1 or Alt 2, a same 3 step approach will be needed: step 1) find a reference slot based on K1; 2) based on the reference slot, find the target cell based on the time pattern; 3) find actual slot and PUCCH resource to transmit on the target cell. The only different between Alt 1 and Alt 2 is whether allow different reference between step 1 and step 2, which is secondary. The primary open issue is to agree on the 3 steps procedure. |
| China Telecom | The reference cell for the k1 interpretation is the PCell / PScell the same as no PUCCH carrier switching as the PUCCH carrier is determined after determining the PUCCH slot using k1.  However, we think the reference cell/SCS of time-domain pattern should prevent the PUCCH carrier change in the middle of a slot for a cell in the mixed numerology cases. The reference cell of time-domain pattern could be an RRC configured PUCCH cell having the smallest SCS among PUCCH cells, or has the same SCS as referenceSubcarrierSpacing of TDD DL-UL configuration, which may be different from the PCell / PScell.  Moderator: Just to check, what would be the advantage of having a reference numerology in addition? Couldn’t then the reference cell be used also to do this (and using a cell with the smallest SCS as proposed by some companies)  ==>CTC: More interpretation in 1st check point proposal 6.7. |
| FGI/APT | We support Alt.1 |
| LG | Support Alt. 1 |

**Reference cell definition**

As it is clear, that at least a reference cell is needed for the k1 interpretation, let’s get feedback on how the reference cell is defined. Please note, that if there is separate k1 configuration per PUCCH cell it is not sufficient to say ‘PUCCH cell’ of smallest or largest SCS, as there may be more than one PUCCH cell of the same smallest or largest SCS with different K1 sets configured. **Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below.**

**Question 6.7: For semi-static PUCCH carrier switching, the reference cell is defined as:**

* **Alt. 1: the PCell / PScell** 
  + **Supporting companies: Nokia/NSB, OPPO, Panasonic, Ericsson, DOCOMO, QC, NEC, China Telecom, Huawei, LG, FGI/APT, Spreadtrum** …
* **Alt. 2: an RRC configured PUCCH cell of any numerology** 
  + **Supporting companies: vivo (2nd preference), ZTE, FGI/APT,** …
* **Alt. 3: an RRC configured PUCCH cell having the smallest SCS among PUCCH cells** 
  + **Supporting companies: vivo (1st preference), CATT, LG, FGI/APT,** …
* **Alt. 4: an RRC configured PUCCH cell having the largest SCS among PUCCH cells** 
  + **Supporting companies: NEC**…
* **Alt. 5: other**
  + **Supporting companies:** …

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| *Company* | *Comments or Alt. 5 / other* |
| OPPO | Alt 1 |
| vivo | Alt.2 and Alt.3 can achieve Alt.1; in addition, Alt.3 is slightly preferred to reduce the discussion cases for mixed numerology. |
| Ericsson | Alt 1.  We think Alt.1 can also handle the mixed numerology. As we proposed, that is simply done by configuring cell-offset in addition as part of time pattern. |
| ZTE | Alt 2 is more flexible and can include Alt.1 |
| Samsung | This proposal/question seems to jump ahead by assuming that Alt.1 in Q6.6 is agreed. May discuss Q6.7 if/after introduction of a “reference cell” is agreed.  There is no apparent reason for introducing either a “reference SCS” or a “reference cell”. Concluding on the slots corresponding to the time pattern is sufficient. |
| Spreadtrum | Alt 1 |
| NEC | Alt.1 or Alt.4.  Alt.1 is simple. Alt.4 has smallest time granularity for time pattern configuration, which can achieve most flexible target cell configuration. |
| China Telecom | We suggest to modify the subject as:  **For semi-static PUCCH carrier switching, the reference cell for the k1 interpretation is defined as:**  The reference cell for the k1 interpretation is the PCell / PScell the same as no PUCCH carrier switching as the PUCCH carrier is determined after determining the PUCCH slot using k1. |
| FGI/APT | Alt.1, Alt.2 and Alt.3 are both fine. |
| LG | Alt. 1 or Alt. 3 |

**Support for other UCI types**

There had been slightly different opinions, if in addition to HARQ-ACK from PCell/PSCell also CSI and/or SR could be multiplexed on the semi-statically configured PUCCH cell (other than Pcell/PSCell). **Please add your companies name directly to the Alternatives in the question, and provide your additional comments or alternatives in the table below.**

**Question 6.8: For semi-static PUCCH carrier switching, in addition to HARQ-Ack from Pcell/PSCell the following UCI types are supported to be multiplexed on the semi-statically determined target PUCCH cell:**

* **Alt. 1: SR**
  + **Supporting companies: Nokia/NSB, OPPO, vivo, Panasonic, ZTE, DOCOMO, ETRI, CATT, China Telecom, Huawei** …
  + **Companies not supporting:** …
* **Alt. 2: P-CSI / SP-CSI**
  + **Supporting companies: Nokia/NSB, OPPO, vivo, Panasonic, ZTE, DOCOMO, ETRI, CATT, China Telecom, Huawei** …
  + **Companies not supporting:** …
* **Alt. 3: Other**
  + **Supporting companies: QC,**…

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| *Company* | *Comments or Alt. 3 / other* |
| Nokia, NSB | As the time-domain pattern is fixed and RRC configured, there is no need to prevent SR and CSI operation (in contrast to dynamic indication, where we think only SR should be supported). |
| OPPO | Alt1 and Alt 2 |
| vivo | As SR and CSI are semi-static configured, semi-static PUCCH carrier switching can be applied to them naturally. At the same time, Rel-15/16 UCI multiplexing/prioritization rules can be reused since only one PUCCH cell is applicable at any time. |
| Ericsson | Same comment as before for the similar question as dynamic (copied below).  One comment as before: **HARQ-Ack from Pcell/PSCell** is not correct.  With correction below, we support both Alt-1 and Alt-2. We suggest change Alt-3 as following. It is not clear why an Alt with all of them is excluded.  This proposal overlaps with 6.3 to some extent and discussion before.  **For dynamic PUCCH carrier indication, in addition to HARQ-Ack ~~from Pcell/PSCell~~, the following UCI types are supported to be multiplexed on the indicated PUCCH cell:**   * **Alt. 3: SR, P-CSI, SP-CSI, HARQ-ACK for DL SPS…**   Moderator reply: Good suggestion for the first half-sentence, thanks. |
| DOCOMO | If PUCCH carrier switching is not supported for certain UCI type, we may need to determine UE behavior for following cases:   * Is multiplexing of HARQ-ACK and other UCI (e.g. CSI) before or after semi-static PUCCH carrier switching for HARQ-ACK?   + If multiplexing is before PUCCH carrier switching, can PUCCH carrier switching be applicable for the multiplexed UCI?   + If multiplexing is after PUCCH carrier switching, multiplexing of HARQ-ACK and other UCI on different cells may need to be defined.   If PUCCH carrier switching is supported for any UCI type, the simplest behavior is to perform UCI multiplexing on Pcell first, then perform PUCCH carrier switching for the multiplexed PUCCH. |
| Samsung | Same comment as E/// and with reference to the comment for the DCI-based indication. |
| QC | We are confused by the question. We don’t see why “multiplexing” is emphasized here. Like we mentioned before, we don’t support cross CC PUCCH multiplexing on PUCCH. To us, the question should be: Whether support transmitting CSI or SR on Scell(s) via carrier switch by DCI or by time pattern configuration (where the CSI or SR does not overlap with other PUCCH on other cells). It is like the question on HARQ-ACK we ask ourself before: when there is a SR bit, is UE allow to transmit it on a Scell with earlier UL slot? Couple this with UCI multiplexing unnecessarily complicates things. We suggest RAN1 to discussion SR and CSI carrier switch without considering multiplexing first. After that, we can discuss the multiplexing scenario.  Moderator reply: Good point, for semi-static this may be slightly different compared to dynamic indication (where neither SR nor P-CSI/SP-CSI is not dynamically triggered) |
| NEC | We are fine with updated proposal from Ericsson. |
| LG | Support Alt. 1 |
| Lenovo/Motorola Mobility | Legacy multi-UCI multiplexing/dropping rules should be applied to PUCCH carrier switching. |

* 1. 1st checkpoint (Aug 19th)

**Generic for PUCCH carrier switching**

On the TPC, companies agree to support independent TPC based on proposal 6.1. There had been one comment, that maybe the separate TPC indication using DCI format 2\_2 should be put for the moment as FFS.

So the following is proposed to be agreed:

**Mod. Proposal 6.1: For PUCCH carrier /cell switching, support independent TPC per PUCCH cell including**

* **Separate P0 / TPC configuration per PUCCH cell**
  + ***Note: This flexibility is already provided as PUCCH-config is per UL BWP of a PUCCH cell***
* **Accumulating closed loop power control commands only within the same target cell by reusing Rel-15 procedure, i.e.** 
  + **For dynamic PUCCH cell indication, the TPC command in the DCI scheduling the PUCCH only applies for the dynamically indicated PUCCH target cell**
  + **For semi-static / time-domain pattern, the TPC command in the DCI scheduling the PUCCH only applies for the determined PUCCH target (using the time-domain pattern)**
* **FFS: Separate TPC command indication using DCI format 2\_2 for the individual PUCCH cells**
  + ***Note: this requires configuration of individual TPC command starting points for each PUCCH cell within DCI format 2\_2***

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| Supporting companies | Nokia/NSB, NEC, QC, Samsung, LG, CATT, vivo, ZTE, Intel, Mediatek |
| Objecting companies |  |

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| --- | --- |
| *Company* | *Comments* |
| QC | Regarding the FFS on group common TPC for PUCCH with carrier switch, “**Separate TPC command indication using DCI format 2\_2 for the individual PUCCH cells**” is one of the methods to do it. This method needs RRC to configure TPC command position indicator for every CC. Another way to do it is similar to the group common TPC for PUSCH, where a UL CC index (on which the TPCs are applied to) is associated with a DL CC index where the DCI 2\_2 is monitored. The third method is adding the CC index indication field in the TPC commands in DCI 2\_2. There may be other methods to do it. We are open to discuss this topic. |
| Samsung | Would be good to conclude on the separate TPC commands for DCI 2\_2 (without the note – can be up to RAN2 how). There does not seem to be anything to FFS. |
| Huawei | We are generally fine with the proposal. One suggestion on wording is to unify the term of “PUCCH carrier”/”PUCCH cell”. Align with the title, “PUCCH carrier switching” of this topic, we recommend to modify as below:  **For PUCCH carrier switching, support independent TPC per PUCCH ~~cell~~ carrier including**   * **Separate P0 / TPC configuration per PUCCH ~~cell~~ carrier**   + ***Note: This flexibility is already provided as PUCCH-config is per UL BWP of a PUCCH* ~~cell~~ carrier** * **Accumulating closed loop power control commands only within the same target ~~cell~~ carrier by reusing Rel-15 procedure, i.e.**    + **For dynamic PUCCH ~~cell~~ carrier indication, the TPC command in the DCI scheduling the PUCCH only applies for the dynamically indicated PUCCH target ~~cell~~ carrier**   + **For semi-static / time-domain pattern, the TPC command in the DCI scheduling the PUCCH only applies for the determined PUCCH target (using the time-domain pattern)** * **FFS: Separate TPC command indication using DCI format 2\_2 for the individual PUCCH ~~cell~~ carrier**   + ***Note: this requires configuration of individual TPC command starting points for each PUCCH* ~~cell~~ carrier *within DCI format 2\_2***   Moderator: Do agree that consistent formulation would be needed, but please note that in the RAN1 specs we usually talk about cells (and not carrier). E.g. in Rel-16 it is called ‘PUCCH-Scell’, so better to use the cell notation.  I propose for all agreements in this meeting to talk about **PUCCH carrier / cell switching** in this meeting, and from RAN1#107-e to talk about PUCCH cell switching (incl. RRC parameters, UE capabiltities etc.)? Would this be acceptable to Huawei?  Added the **PUCCH carrier / cell switching** to all proposals. |
| Mediatek | A new DCI bit-field could be included in DCI format 2\_2 to indicate the PUCCH carrier on which the TPC command applies |
|  |  |

**Dynamic PUCCH cell indication**

**Target PUCCH cell indication**

There had been no negative feedback the following proposal, which is suggested to be agreed:

**Proposal 6.3: UE does not expect overlapping PUCCHs with dynamic PUCCH cell indication on more than one carrier, i.e. gNB should only dynamically indicate a single PUCCH cell for a final PUCCH slot.**

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| Supporting companies | OPPO, vivo, Panasonic, ZTE, DOCOMO, Spreadtrum, QC,NEC, CATT, China Telecom, Huawei, Ericsson, Samsung, LG, Intel, Mediatek, FGI/APT |
| Objecting companies |  |

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| --- | --- |
| *Company* | *Comments* |
| Samsung | We understand the above to not imply that “semi-static PUCCH + dynamic PUCCH” overlapping on different cells can be expected by the UE – i.e. that case is not addressed by the proposal - otherwise, we do not agree to the proposal.  Moderator: this was the moderator’s intention, to only handle the case of e.g. two PUCCHs where each of them had a dynamic indication of the PUCCH carrier, but a different on. If you have a better wording in mind to clarify this, please let us know. |
| Huawei | Same suggestion as for Proposal 6.1 on unifying the term as below:  **UE does not expect overlapping PUCCHs with dynamic PUCCH ~~cell~~ carrier indication on more than one carrier, i.e. gNB should only dynamically indicate a single PUCCH ~~cell~~ carrier for a final PUCCH slot.** |
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**Semi-static PUCCH cell indication**

**Pattern definition and pattern usage:**

There had been good feedback on the definition (nobody opposing) and therefore, the following modified proposal is suggested to be agreed. This includes the feedback received on Question 6.6, where majority of companies think a reference cell would be better suited for the pattern definition.

**Modified Proposal 6.4: For semi-static PUCCH carrier /cell switching, the time-domain pattern configuration is based on the following properties:**

* **A single time-domain pattern is configured per PUCCH cell group**
* **The granularity of the time-domain pattern is one slot of the ~~reference numerology /~~ reference cell**
  + ***FFS definition of ~~reference numerology /~~ reference cell***
* **The ~~length of the~~ time-domain pattern is applied periodically ~~one frame (i.e. 10ms)~~**
  + FFS on period / pattern length (e.g. 10ms, RRC configured,…).
* **The pattern defines for each slot of the ~~reference numerology /~~ reference cell the applicable PUCCH cell**

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| Supporting companies | Nokia/NSB, NEC, QC, LG, CATT, OPPO, CMCC, vivo, China Telecom, ZTE, Intel, Huawei, Mediatek, FGI/APT, Lenovo/Motorola Mobility |
| Objecting companies | Samsung |

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| --- | --- |
| *Company* | *Comments* |
| QC | Editorial “**The pattern defines for each slot of the ~~reference numerology /~~ reference cell the applicable PUCCH cell**”  Moderator: thanks - updated |
| Samsung | No need to define a ‘reference cell’. The *time* pattern is not defined with respect to cells, it is defined with respect to slots.  If the intention is to conclude that the slot is that of the PCell, we’re OK to do so but we do not support developing specifications for the case that the PCell has larger SCS as they are unlikely to be same (and are likely to be more complex) compared to the case that the PCell has smaller SCS.  Moderator: when looking at the following proposals, if this proposal and proposal 6.7 is agreed together, we have what Samsung has in mind. The problem for the moderator is only, that there are of course different opinions (as always). And then there is no need to introduce any reference cell in the specifications! |
| Huawei | Same suggestion as for Proposal 6.1 on unifying the term as below:  **For semi-static PUCCH carrier switching, the time-domain pattern configuration is based on the following properties:**   * **A single time-domain pattern is configured per PUCCH cell group** * **The granularity of the time-domain pattern is one slot of the ~~reference numerology /~~ reference cell**   + ***FFS definition of ~~reference numerology /~~ reference cell*** * **The ~~length of the~~ time-domain pattern is applied periodically ~~one frame (i.e. 10ms)~~**   + FFS on period / pattern length (e.g. 10ms, RRC configured,…).   **The pattern defines for each slot of the ~~reference numerology /~~ reference cell the applicable PUCCH ~~cell~~ carrier** |
| Mediatek | The other option is to have PUCCH time-domain pattern configured per SPS configuration. |
|  |  |

**K1 and PRI interpretation**

**On the k1 and PRI interpretation for semi-static PUCCH carrier switching:** There had only been positive feedback – one company mentioning, that this should be clear and also apply to TPC. So the following two proposals are suggested to be agreed:

**Proposal 6.5: For semi-static PUCCH carrier /cell switching, the PDSCH to HARQ-ACK offset k1 is interpreted based on the numerology and PUCCH configuration of a reference cell to be able to apply the time-domain PUCCH carrier switching pattern.**

* + ***FFS definition of reference cell***

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| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, ZTE, DOCOMO, QC, NEC, CATT, China Telecom, FGI/APT, LG, Huawei, [Samsung], Intel, Mediatek |
| Objecting companies | Samsung |

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| --- | --- |
| *Company* | *Comments* |
| Samsung | OK if “reference cell” is removed. This is semantics and not substance, but there is no justified reason for introducing a “reference cell”. May revisit this proposal after concluding on 6.4.  Moderator: see also comment to 6.4, if 6.7 is agreed also I guess this is what Samsung is having in mind there. |
| Mediatek | The reference cell is the target PUCCH cell as in the dynamic PUCCH carrier switching. No need to change the definition for the semi-static case. |
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**Proposal 6.6: For semi-static PUCCH carrier /cell switching, the PUCCH resource indicator (PRI) is interpreted based on the PUCCH configuration of determined target PUCCH cell.**

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| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, ZTE, DOCOMO, QC, NEC, CATT, China Telecom, FGI/APT, LG, Huawei, Lenovo/Motorola Mobility, Samsung, Intel, Mediatek |
| Objecting companies |  |

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| --- | --- |
| *Company* | *Comments* |
| Huawei | Same suggestion as for Proposal 6.1 on unifying the term as below:  **For semi-static PUCCH carrier switching, the PUCCH resource indicator (PRI) is interpreted based on the PUCCH configuration of determined target PUCCH ~~cell~~ carrier.** |
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**Reference cell definition**

Looking at the feedback received during the 1st round on question 6.7, the follow can be noted:

* 12 companies support Alt. 1, using PCell/PSCell as the reference cell
* Only 3 companies not supporting Alt. 1, request either Alt. 2 or Alt. 3

Therefore, the following proposal is brought forward:

**Proposal 6.7: For semi-static PUCCH carrier /cell switching, the PCell / PScell is used as reference cell.**

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| Supporting companies | Nokia/NSB, OPPO, Panasonic, Ericsson, DOCOMO, QC, NEC, China Telecom(for K1 interpretation), Huawei, LG, FGI/APT, Spreadtrum, CMCC, Mediatek |
| Objecting companies | Samsung, CATT, vivo, China Telecom(for granularity of the time-domain pattern) |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | We can be supportive to use the PCell SCS for determining the time pattern subject to not duplicating specifications in order to cover both the smaller/larger SCS cases. The present work is still under the “aim for minimum specification impact” agreement.  Also, as previously mentioned, we do not see any reason to define “reference cell”.  Moderator: see also comments to 6.4 and 6.5. If we get these agreed together, there is no need to define the reference cell, as PCell/Scell can then replace the reference cell for all the agreements. |
| CATT | We would like to discuss the case when the SCS of PCell/Pscell is larger. In this case, is it possible that the target PUCCH carriers for multiple slots of PCell/Pscell within a slot of a SCell are different? If so, what are the UE behaviors?  In addition, we would like to clarify whether K1 set needs to be configured for the candidate PUCCH SCell?  Moderator: on the multiple target carrier slots overlapping with a single PCell slot, which slot too chose is the same if there is a single or more than one target carrier overlapping. Mixed SCS handling needed.  On the K1 configuration need, this depends on how we define the case of one PCell slot overlapping with more than one target PUCCH cell slot. If some rule is applied (e.g. first overlapping slot) or something is RRC configured, then there seems to be no need. But this is for further discussion with respect to mixed SCS / PUCCH slot length handling. |
| vivo | Alt.3 or Alt.2 is our preference. Since it is more flexible and can realize Alt.1 (PCell / PScell as reference cell.).  Moderator: we all know the preferences from companies from the first round. Any specific reason to object or is vivo thinking to convince the 10+ companies still? |
| China Telecom | We support PCell/PScell as reference cell for k1 interpretation with semi-static PUCCH carrier switching.  However, for granularity of the time-domain pattern, we prefer using an RRC configured PUCCH cell having the smallest SCS among PUCCH cells as the reference cell. The reason is if PCell/PScell is used as the reference cell for configuring the time-domain pattern, and there is another PUCCH cell 1 whose SCS is smaller than the PCell/PScell, to prevent the PUCCH carrier change in the middle of a slot for PUCCH cell 1, there should be restriction for the time-domain pattern configuration. To make the time-domain pattern configuration easier without considering such restriction, why not using the smallest SCS PUCCH cell as the reference cell?  Moderator comment: please check the input given to Question 6.6 in Round 1, CTC was unfortunately alone on this respect there. One may need to consider how big you see the chances to convince the other companies there? |
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**Support for other UCI types**

The feedback on question 6.8 was in general that semi-static PUCCH carrier switching for all UCI types should be supported, as at a single time a certain PUCCH cell is applicable and the cell may contain also CSI and/or SR configuration for each UL BWP. There had been suggestions to change the wording, which have been taken into account here. Therefore, the following is proposed:

**Proposal 6.8: Semi-static PUCCH carrier /cell switching is applicable to all UCI types incl. HARQ-ACK, SR and CSI.**

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| Supporting companies | Nokia/NSB, NEC, Samsung, CATT, OPPO, CMCC, vivo, China Telecom, ZTE, Huawei, Mediatek, Lenovo/Motorola Mobility |
| Objecting companies |  |

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| --- | --- |
| *Company* | *Comments* |
| Samsung | The support is both for best utilization of the feature and for complying with the “aim for minimum specification impact” from the agreement. |
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* 1. 2nd Round and 3rd Round of email discussions

**Terminology PUCCH cell or PUCCH carrier**

Huawei objected to all 1st check-up proposals with the argument, that the feature is called ‘PUCCH carrier switching’ and therefore, we should talk about ‘PUCCH carrier’ instead of ‘PUCCH cell’ for all agreements we make. The argument being the SUL handling.

Qualcomm in a reply on the reflector noted, that we made the initial agreements to support the feature during RAN1#105-e using the ‘PUCCH cell’ terminology already. Therefore, this is no need to change this here now.

As this issue before being solved could jeopardize the progress (as no decisions can be taken, if Huawei blocking all agreements using the RAN1#105-e notation), the moderator suggests to put specific focus for the 3rd round on this issue.

Let’s see where companies stand by the following question:

**Question 6.4.1: On the notation of ‘PUCCH carrier switching’, the following is to be used:**

* **Alt. 1: Continue to use the current notation used up Rel-106-e of calling the feature ‘PUCCH carrier switching’ but otherwise using ‘PUCCH cell’**
* **Alt. 2: Use the notation of ‘PUCCH carrier switching’ as done so far for the name of the feature, but for any further agreements replace ‘PUCCH target/reference cell’ with ‘PUCCH target/reference carrier’ (as suggested by Huawei)**
* **Alt. 3: Other**

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| --- | --- |
| Alt. 1 | Nokia/NSB, QC, DOCOMO, Samsung, FGI/APT, ZTE, Panasonic |
| Alt. 2 | Huawei (with some modification as below), Xiaomi, China Telecom, CMCC |
| Atl. 3 |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Huawei | From our side, PUCCH carrier switching feature literally means the switching between carriers, i.e. including both NUL and SUL, otherwise no need to call it PUCCH carrier switching. However, it seems some company has different view. We can accept to further clarify to align the views in the whole group, in order to make the following discussion more smoothly. Many thanks to the moderator and all companies for your great effort.  Using PUCCH carrier switching can cover all cases, i.e. all the following three cases are covered:  **Case 1**: do PUCCH switching among different cells with each cell only configured with NUL  **Case 2**: do PUCCH switching among different cells with some of the cell(s) configured with both NUL and SUL  **Case 3**: do PUCCH switching among NUL and SUL of a single cell  However, if PUCCH switching can only be done among the cells, only case 1 and case 2 above can be supported. In our understanding, case 3 should not be excluded and no reason to preclude case 3, since it is expected uniform solution can be applied to all 3 cases and it can allow case 3 to achieve the benefit from dynamic PUCCH switching also.  For example, For a cell which includes a NUL carrier (e.g., 3.5GHz) and a SUL carrier (e.g., 1.8GHz UL) as shown in the figure below, enabling the PUCCH carrier switching between 3.5GHz and 1.8GHz would take all the benefits we have discussed previously (improved UL resource availability for faster HARQ/scheduling; PUCCH offloading among carriers, etc.). Otherwise, if PUCCH switching merely between cells is supported, the SUL cell has to fixedly choose only one carrier for PUCCH transmission and fails to get such benefits.    In addition, being compatible with as many as possible legacy features will promote the value of the PUCCH carrier switching instead of degrading it, especially regarding the SUL feature has been commercialized at the moment. Not allowing it to evolve may potentially limit the application cases of PUCCH carrier switching.  From the specification view, it should be noted that the basic logic (including the carrier indication design for dynamic switching, the time pattern design for semi-static switching, the handling of overlapping/multiplexing, reference carrier for TPC/HARQ, codebook construction, etc.) of PUCCH carrier switching will not be impacted due to case 3, i.e. uniform design is possible.  Therefore, Alt.2 with the modification below shall be adopted. Note that the modification is to match the following proposals better.  **Alt. 2: Use the notation of ‘PUCCH carrier switching’ as done so far for the name of the feature, but for any further agreements replace ‘PUCCH/target/reference cell’ with ‘PUCCH/target/reference carrier’ (as suggested by Huawei)**  Moderator: question updated |
| Nokia/NSB | We don’t see a need for changing the terminology used so far. |
| QC | We understand HW’s intention is to enable dynamic PUCCH switch between SUL and NUL. However, to me, this is a separate new feature, which is not agreed yet, because what we discussed so far is actually PUCCH cell switch. If we looked at the agreements we made in last meeting (copied below), all the bullets are about PUCCH cell switch. Yes, the feature name is called carrier switch. But the naming of a feature does not matter that much (we can call it super PUCCH by the way, which I think is a better naming for the feature 😊). What matter is the agreed functionality of the feature.  **For dynamic switch between SUL and NUL, a new agreement will be needed to support it.**  With the above, I think RAN1 should be consistent to follow the notation used in previous agreements, which is Alt 1.  Agreement: Support PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH and semi-static configuration   * Details are FFS (including applicability of dynamic and/or semi-static means) * Aim for minimum specification impact * Dynamic indication and/or semi-static configuration are subject to separate UE capabilities * The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH **cell** timing pattern of applicable PUCCH **cells** and supports PUCCH carrier switching across **cells** with different numerologies.   + FFS whether additional rules are needed to support PUCCH carrier switching across **cells** with different numerologies * FFS the maximum number of PUCCH **cells** * FFS whether and how to support joint operation of dynamic and semi-static carrier switching for a UE * FFS whether and how to support joint operation of PUCCH carrier switching and SPS HARQ-ACK deferral   Agreement: For PUCCH carrier switching, the PUCCH resource configuration is per UL BWP (i.e. per candidate **cell** and UL BWP of that specific candidate **cell**).  Agreement: For PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH (i.e. Alt. 1), the PDSCH to HARQ-ACK offset k1 is interpreted based on the numerology of the dynamically indicated target PUCCH **cell**. |
| DOCOMO | We share similar view with Qualcomm. |
| CATT | We are open to discuss whether dynamic carrier switching between NUL and SUL within a single cell is supported or not. |
| Samsung | RAN1 terminology has sometimes been inconsistent – e.g. we still use “carrier aggregation” when it is “cell aggregation”. Based on the agreement, we also had the understanding for “PUCCH carrier switching” to mean “cell switching” and used that terminology in all our proposals and discussions (except keeping “PUCCH carrier switching” similar to keeping “carrier aggregation”). Our understanding has been Alt. 1.  Although it can be reasonably argued to include SUL, the whole topic was agreed under the premise of “aim for minimum specification impact”. That is a part of the agreement that we would strongly prefer to abide by and strictly enforce. Introduction of SUL would introduce yet another dimension to “PUCCH carrier switching” and complicate the overall design. |
| Xiaomi | We think PUCCH carrier switching should be self-explanatory, the switching can occur among different carriers not cells, so the switching among multiple carriers of one single cell should not be excluded. |
| Spreadtrum | We keep open mind to discuss whether support switching among NUL and SUL of a single cell since it has certain beneficial of scheduling flexibility. |
| China Telecom | Enabling PUCCH carrier switching between SUL and NUL makes the benefits of the feature be applicable to the single cell Case 3 as listed by HW by uniform specification design, we think we should not preclude it. |
| CMCC | We think it is good to have case 3 (NUL-SUL switch) supported in this feature, because that is likely a valid scenario for us: n41 as NUL carrier and accompanied with another possible SUL carrier to extend the coverage and capacity.  Having said this, exactly how much is the spec impact we are looking at? |
| Intel | Open to discuss NUL and SUL switching separately |
| vivo | We are open to discuss whether to support dynamic switch between the SUL and NUL. |
| Huawei2 | First about the spec impact as we clarified in the beginning, as the major impact to spec is to replace ‘Cell’ to ‘Carrier’ at least for the proposals waiting for approval. So including NUL/SUL PUCCH switching does not violate the principle of “aim for minimum specification impact” as we agreed before.  Second about the notation. We believe that the title should be consistent with the content/functionality to avoid ambiguity, unless they have no conflict meanings as “carrier aggregation” and “cell aggregation”. We think the legacy feature of SUL is naturally included in the PUCCH carrier switching feature literally interpreted by its title. If we have different understandings on such ambiguity, clarifications are necessary as what we are doing now. As to the content/functionality, since the discussion of the functionality is still ongoing, it is not a big effort if we can add some notes to clarify the ‘cell’ and ‘carrier’ issue and make the feature more comprehensive and more compatible.  Third about the commercial value. If the NUL/SUL switching cannot be covered in R17 PUCCH carrier switching, the network operators/partners who have already deployed/developed this feature can hardly evolve to R17, which causes great loss and even larger effort on future network evolving, and the value of this feature will be critically harmed.  Kindly add Xiaomi’s comments into the list which was missed during the combination. |
| Xiaomi | We think PUCCH carrier switching should be self-explanatory, the switching can occur among different carriers not cells, so the switching among multiple carriers of one single cell should not be excluded. |

**Proposals from 1st check-point referred here (please note, the original formulation is used, any decision on the notation of PUCCH cell /PUCCH carrier is to be applied in the end)**

As the header says, we can adopt the notation to be used (based on the input on Question 6.4.1) to all proposals. **So please Huawei, don’t just object here because of notation. This is to be decided separately.**

On proposal 6.1, there had been question if we need **independent TPC** commands using DCI format 2\_2 (which was still for FFS). Let’s get companies input on what they think here separately by a questions, maybe we can based on the outcome of the question thereby resolve if to remove the FFS from Mod Proposal 6.1:

**Question 6.4.1: For independent TPC per PUCCH cell, should separate TPC command indications in DCI format 2\_2 be available for the individual PUCCH cells?**

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| --- | --- |
| Yes | Nokia/NSB, QC, DOCOMO, vivo, CATT, Samsung, ZTE, NEC, Intel |
| No |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | When having independent TPC loops for different PUCCH cells, it is essential to have the same flexibility also using DCI format 2\_2. And this is not the first time we do this (when looking at Rel-16 enhancements). |
| QC | Maybe there was some confusion about QC’s previous comment on this. We are not objecting having separate TPC command indication for DCI format 2\_2. Our comment is about whether the TPC command position configuration should follow the PUCCH or PUSCH TPC command position configuration framework. We think both could work but maybe a decision on this is needed to pick one.  Moderator: thanks for clarifying, maybe this is one thing to discuss in the RRC parameter discussions following RAN1#106-e. Clearly some communalities would be appreciated (for min. specs impact otherwise). |
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**Mod. Proposal 6.1: For PUCCH carrier switching, support independent TPC per PUCCH cell including**

* **Separate P0 / TPC configuration per PUCCH cell**
  + ***Note: This flexibility is already provided as PUCCH-config is per UL BWP of a PUCCH cell***
* **Accumulating closed loop power control commands only within the same target cell by reusing Rel-15 procedure, i.e.** 
  + **For dynamic PUCCH cell indication, the TPC command in the DCI scheduling the PUCCH only applies for the dynamically indicated PUCCH target cell**
  + **For semi-static / time-domain pattern, the TPC command in the DCI scheduling the PUCCH only applies for the determined PUCCH target (using the time-domain pattern)**
* **FFS: Separate TPC command indication using DCI format 2\_2 for the individual PUCCH cells**
  + ***Note: this requires configuration of individual TPC command starting points for each PUCCH cell within DCI format 2\_2***

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| Supporting companies | Nokia/NSB, NEC, QC, Samsung, LG, CATT, vivo, ZTE, Intel, Mediatek, [Samsung], Huawei (if the notation in 6.4.1 goes Alt.2), DOCOMO, Xiaomi |
| Objecting companies |  |

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| *Company* | *Comments* |
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There had only been the notation objection on Proposal 6.3, therefore, this is still proposed unchanged:

**Mod. Proposal 6.3: UE does not expect overlapping PUCCH slots with dynamic PUCCH cell indication on more than one carrier, i.e. gNB should only dynamically indicate a single PUCCH cell for a final PUCCH slot.**

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| --- | --- |
| Supporting companies | OPPO, vivo, Panasonic, ZTE, DOCOMO, Spreadtrum, QC,NEC, CATT, China Telecom, Ericsson, Samsung, LG, Intel, Mediatek, FGI/APT, Huawei (if the notation in Question 6.4.1 goes Alt.2), Lenovo/Motorola Mobility, Spreadtrum, CMCC, Xiaomi |
| Objecting companies |  |

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| --- | --- |
| *Company* | *Comments* |
| DOCOMO | Very sorry for raising the issue too late. Just for clarification, we propose to modify the proposal into:  **UE does not expect overlapping PUCCH slots with dynamic PUCCH cell indication on more than one carrier, i.e. gNB should only dynamically indicate a single PUCCH cell for a final PUCCH slot.**  With the modification, it is better aligned with the description by “i.e. gNB should only dynamically indicate a single PUCCH cell for a final PUCCH slot”.  Moderator: thanks – updated. |
| ZTE | Fine with the update of **slots** |
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There had only been the notation objection on Proposal 6.4, but Samsung raise the issue if a reference cell needs to be defined or introduce the specification or not. To address this a related note is added, that this does not mean that the ‘reference cell’ needs to be introduced in the RAN1 specifications. therefore, this is still proposed unchanged:

**Mod2 Proposal 6.4: For semi-static PUCCH carrier switching, the time-domain pattern configuration is based on the following properties:**

* **A single time-domain pattern is configured per PUCCH cell group**
* **The granularity of the time-domain pattern is one slot of the ~~reference numerology /~~ reference cell**
  + ***~~FFS definition of reference numerology / reference cell~~***
  + ***FFS: how to determine the reference cell***
  + ***Note: the notation of a reference cell may not need to be introduced in the RAN1 specification depending on how the reference cell is to be determined.***
* **The ~~length of the~~ time-domain pattern is applied periodically ~~one frame (i.e. 10ms)~~**
  + FFS on period / pattern length (e.g. 10ms, RRC configured,…).
* **The pattern defines for each slot of the ~~reference numerology /~~ reference cell the applicable PUCCH cell**

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| --- | --- |
| Supporting companies | Nokia/NSB, NEC, QC, LG, CATT, OPPO, CMCC, vivo, China Telecom, ZTE, Intel, Mediatek, FGI/APT, [Samsung], Huawei (if the notation in Question 6.4.1 goes Alt.2), Lenovo/Motorola Mobility, DOCOMO, Spreadtrum, Xiaomi |
| Objecting companies |  |

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| *Company* | *Comments* |
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The same equally applies to Proposal 6.5, where the Samsung concern is tried to be taken into account:

**Mod. Proposal 6.5: For semi-static PUCCH carrier switching, the PDSCH to HARQ-ACK offset k1 is interpreted based on the numerology and PUCCH configuration of a reference cell to be able to apply the time-domain PUCCH carrier switching pattern.**

* + ***~~FFS definition of reference cell~~***
  + ***FFS: how to determine the reference cell***
  + ***Note: the notation of a reference cell may not need to be introduced in the RAN1 specification depending on how the reference cell is to be determined.***

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| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, ZTE, DOCOMO, QC, NEC, CATT, China Telecom, FGI/APT, LG, [Samsung], Intel, Mediatek, Huawei (if the notation in Question 6.4.1 goes Alt.2) , Spreadtrum, CMCC, Xiaomi |
| Objecting companies |  |

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| *Company* | *Comments* |
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There had only been the notation objection on Proposal 6.6, therefore, this is still proposed unchanged:

**Proposal 6.6: For semi-static PUCCH carrier switching, the PUCCH resource indicator (PRI) is interpreted based on the PUCCH configuration of determined target PUCCH cell.**

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| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, ZTE, DOCOMO, QC, NEC, CATT, China Telecom, FGI/APT, LG, Lenovo/Motorola Mobility, Samsung, Intel, Mediatek, Huawei (if the notation in Question 6.4.1 goes Alt.2) , Spreadtrum, CMCC |
| Objecting companies |  |

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| *Company* | *Comments* |
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On proposal 6.7 in addition the notation objection from Huawei, there had been 3 objections, but looking at the situation at hand with 14 companies suggesting to use PCell/PSCell (incl. Huawei) and the 3 objecting companies suggesting two different solutions to apply, convincing the other companies seems to be rather improbable. Earlier objecting companies please re-consider your position by not objecting in 3rd round. Therefore, the proposal stays unchanged except adding the note on the reference cell:

**Mod Proposal 6.7: For semi-static PUCCH carrier switching, the PCell / PScell is used as reference cell.**

* ***Note: the notation of a reference cell may not need to be introduced in the RAN1 specification depending on how the reference cell is to be determined.***

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| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, Panasonic, Ericsson, DOCOMO, QC, NEC, China Telecom(for K1 interpretation), LG, FGI/APT, Spreadtrum, CMCC, Mediatek, [Samsung], Huawei (if the notation in Question 6.4.1 goes Alt.2) , Spreadtrum |
| Objecting companies | Vivo, CATT |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| vivo | If the criterion for selecting one Alternative is for simplicity, smaller specification efforts, then for reference cell determination, we should select Alt.3: RRC configured PUCCH cell having the smallest SCS among PUCCH cells. As commented that, if PCell / PScell is used as reference cell, we need to discuss the mixed numerologies for two cases,   * Case 1: SCS for Pcell as reference cell < SCS for target PUCCH cell. one slot in Pcell overlaps with multi-slots in the target PUCCH cell, discussion is needed on which slot in the target PUCCH cell should be used. * Case 2: SCS for Pcell as reference cell > SCS for the target PUCCH cell; Multi-slot in Pcell overlaps with one slot in the target PUCCH cell, discussion is needed on how to MUX multiple UCIs from multi-slot in Pcell into one slot in the target PUCCH.   But if the reference cell is the one with smallest SCS among PUCCH cells, we only need to discuss case 2. in addition, Alt.3 can achieve Alt.1. We would like to know how Alt.1 is simpler compared to Alt.3 and what are the criterion to select the Alt.1. |
| CATT | Assuming SCS of PCell is 30kHz and SCS of SCell is 15kHz, we would like to understand whether the pattern as follows is allowed, i.e. two slots of PCC within a slot of SCC have different target PUCCH cell.  cid:image002.jpg@01D795D5.54727980  If it is allowed, whether the PUCCH resources of SCC is confined within the second half of the SCC slot? If not, does UE support simultaneous PUCCH transmission on two CCs?  Moderator: Further restrictions will need to be discussed and may be needed. Not just CATT by also Nokia raised this point, that some restriction may be needed there (could be prevented by gNB configuration, i.e. ‘UE does not expect’). I plan to discuss |
| Samsung | OK, subject to not additionally introducing support for the case that the PCell has larger SCS than an SCell for PUCCH. In Rel-17, PUCCH carrier switching should address the more typical use cases and aim for minimum specification impact.  Moderator: I guess we could take a look at the different numerology / slot-length cases in the next round. We may there need to define certain restrictions (e.g. see my reply to CATT above), and for cases where the handling gets too complicated (or seen as not needed), we can take the decision to not support certain operations. |
| China Telecom | We suggest to modify the subject as below and check whether it can be agreed by companies:  **For semi-static PUCCH carrier switching, the PCell / PScell is used as reference cell for the k1 interpretation.**  For the reference cell of the time-domain pattern, maybe we can discuss whether it is allowed PUCCH carrier change in the middle of a slot for the Scell firstly (as questioned by CATT), and then go back to the reference cell determination. |
| CMCC | Is it possible that we only define a “reference slot/raster” for every cell/carrier to look up? This slot/raster does not necessarily link to an actual cell/carrier. This way we may design a “hypothetic cell/carrier” with a fixed and finest slot granularity.  Like China Telecom suggested, currently this reference cell/carrier is just for a time reference of PUCCH resource. |

On the **supported UCI types for SS-PUCCH carrier switching**, in addition to the notation objection from Huawei, Apple objected as they consider this an optimization which may not be needed. The proposal is unchanged, but companies could maybe bring some arguments for Apple to not object in the 3rd round again:

**Proposal 6.8: Semi-static PUCCH carrier switching is applicable to all UCI types incl. HARQ-ACK, SR and CSI.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, NEC, Samsung, CATT, OPPO, CMCC, vivo, China Telecom, ZTE, Mediatek, Huawei (if the notation in Question 6.4.1 goes Alt.2), Lenovo/Motorola Mobility, DOCOMO, FGI/APT |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | The support is both for best utilization of the feature and for complying with the “aim for minimum specification impact” from the agreement. |
| Nokia/NSB | Agree with the comments by Samsung. If we are selective here, we need treat this differently in the specifications. Moreover, when looking at a single slot (e.g. same SCS), the operation is really the same as in Rel-16 but the PUCCH with UCI is transmitted on a different carrier than P/PSCell so no need to differentiate there. |
| DOCOMO | Share the same view as Nokia and Samsung that support for all UCI types will lead to smaller specificatiSSon impact. |
|  |  |
|  |  |

**Generic for PUCCH carrier switching**

**Limitation on maximum number of PUCCH cells within a PUCCH cell group:**

On question 6.1, there seems to be no clear tendency but equally on question 6.2, the positions are rather diverse. Some companies point out, that the maximum number of carriers could be a UE capability (e.g. UE indicating 2 or 4 cells to be supported). Based on this, this may be better discussed later on (e.g. when having some RRC parameter & UE capability discussions).

Thus, the moderator plans no follow-up during (at least) 2nd round and focus on other aspects.

**Dynamic PUCCH cell indication**

**Target PUCCH cell indication**

The input on **Proposal 6.2** with large majority support but having one objecting company (and 3 companies in total not fine), it does not make sense to move this to the checkpoint yet.

**Let’s continue the discussion here from the first round**, with a slightly modified proposal (based on comment by E/// and QC). The moderator would like to point out the comment by Huawei, that the PUCCH resource configuration is per UL BWP, so having a common configuration of a set of resources using PRI does not seem to be that fruitful

**Modified Proposal 6.2: For PUCCH carrier switching based on dynamic indication in the DCI, introduce a new, dedicated DCI field for the DCI scheduling PDSCH to indicate the target PUCCH cell.**

* ***~~FFS: Bit-field width for DCI format 1\_1~~***
* **~~DCI field presence for DCI format 1\_2 is independently RRC configured~~**
  + ***~~FFS: Bit-field width for DCI format 1\_2~~***
* ***~~FFS: If some bit(s) from existing bit fields could be used for DCI format 1\_0~~***

**Please provide you input to the following two tables, first table your company name (for easier checking) and 2nd table for additional comments.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Ericsson (only main bullet), DOCOMO, Samsung, Spreadtrum, QC, NEC, CATT, FGI/APT, Lenovo/Motorola Mobility, Xiaomi, CMCC, China Telecom, Huawei (if the notation in Question 6.4.1 goes Alt.2) |
| Objecting companies | Intel |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | Support, and as discussed in our contribution the bit-field width could be RRC configured for DCI format 1\_1 and 1\_2 (individually). |
| Panasonic | Our preference is to use to use existing PRI field. We agree to have dedicated field will simplify the design. On the other hand, it may imply PUCCH configuration of the source cell is used to the target cell. If dedicated field means PUCCH configuration of the target carrier PUCCH configuration is used, we are ok to have the compromise it. |
| Ericsson | We agree in principle. But we don’t agree on the FFS.  When the field is configured, the size can be based on RRC configured PUCCH cells (X in other proposals). Also, having different sizes for different DCI formats makes the operation complicated. It makes the benefit of PUCCH carrier switching DCI format dependent which is a strange approach in our view. |
| Intel | We think that PRI space for the PCell/PSCell takes into account different UCI multiplexing scenarios etc. When the same PRI space is used for PUCCH carrying HARQ-ACK on another carrier, it is evidently redundant. To optimize the DCI overhead, PRI could encode both PUCCH resource and target carrier. |
| ZTE | Similar with Panasonic & Intel, our choice is to use the existing PRI field as no more additional overhead in DCI. |
| Samsung | 1 bit field (X=2) – the FFS for the field size can be removed. |
| FGI/APT | The DCI field width can be configurable depending on the number of candidate PUCCH cells in the PUCCH cell group. |
| LG | Similar to Intel’s view. Using PRI would be beneficial to keep DCI size and for odd number of PUCCH cells. |
| Huawei | As a clarification, the PRI field is configured per PUCCH-config. The PUCCH resource sets for PRI are not available until a specific carrier index is obtained. |
| Huawei2 | Same suggestion as for Proposal 6.1 on unifying the term as below:  **For PUCCH carrier switching based on dynamic indication in the DCI, introduce a new, dedicated DCI field for the DCI scheduling PDSCH to indicate the target PUCCH ~~cell~~ carrier.** |
| Nokia/NSB | On using the PRI:  1. we agree with Huawei, that the usage of the PRI field is configured per PUCCH-config and therefore per PUCCH cell. Having such ‘new structure’ will create quite some specification impact across different PUCCH configurations  2. We use the PRI already for the dynamic PUCCH repetition indication (see discussions in Sec. 4), having just 3bit PRI and trying to indicate (i) the PUCCH cell, (ii) the number of repetitions and (iii) the PUCCH resource on the PUCCH cell seems to be a bit restrictive. Please note we cannot use the same trick several times, as then in the end the combined operation of the features may not be working anymore. And what is more worrying, we run out of signaling options with 3bits / 8 states. |

Looking at the input from different companies during the first round on Question 6.3, it can be noted that there seems to be good support for Alt. 2, Alt. 3 and Alt. 4 (and no company questioning this). For Alt. 1 there are more companies suggesting not to support than to support. On Alt. 5 there are only negative responses. On the new alternative 6, there is support by a single company.

Therefore it is suggested, that we could maybe in this meeting agree to the subset of Alt. 2, 3 and 4 and have some FFS on additional handling (such as Alt. 6).

**Modified Proposal 6.4.1: In addition to HARQ-Ack of PDSCH dynamically scheduled by a DCI indicating a PUCCH carrier, the dynamic target carrier indication also applies to:**

* **HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI based on the indication in the activation DCI**
* **HARQ-ACK corresponding to the SPS Release DCI based on the indication in the release DCI**
* **triggered PUCCH for Rel-16 Type 3 CB, Rel-17 enh. Type 3 CB of smaller size and Rel-17 one-shot triggering for HARQ-Ack retransmission based on the indication in the triggering DCI**
* ***FFS: additional cases***

|  |  |
| --- | --- |
| Supporting companies | NEC, QC, Samsung, DOCOMO, LG, CATT ~~(with changes)~~, OPPO, vivo, ZTE, Huawei, Mediatek, Nokia/NSB, FGI/APT, , Spreadtrum, Intel |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | Would be simpler to say “all HARQ-ACK associated with the DCI format” as there is also SCell dormancy and whatever else may come up.  Also, the agreement did not restrict any HARQ-ACK type and in that sense the proposal may not be necessary. |
| CATT | For SPS PDSCH, there is no corresponding HARQ-ACK for the activation DCI. The HARQ-ACK is for the first activated SPS PDSCH. Therefore, we propose to change the wording as follows.  **Proposal 6.4.1: In addition to HARQ-Ack of PDSCH dynamically scheduled by a DCI indicating a PUCCH carrier, the dynamic target carrier indication also applies to:**   * **HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI based on the indication in the activation DCI** * **HARQ-ACK corresponding to the SPS Release DCI based on the indication in the release DCI** * **triggered PUCCH for Rel-16 Type 3 CB, Rel-17 enh. Type 3 CB of smaller size and Rel-17 one-shot triggering for HARQ-Ack retransmission based on the indication in the triggering DCI** * ***FFS: additional cases***   Moderator: adopted accordingly |
| Apple | CATT’s proposal is fine. |
| Moderator | CATT proposed correction (I was not precise) adopted |
| Lenovo/Motorola Mobiltiy | The feature should be applicable to all HARQ-ACK with a corresponding DCI format. |
| ZTE | Fine with the update from CATT. It is more precise. |

**HARQ-ACK multiplexing between PCell/SPCell and target cell (incl. other UCI types)**

On Question 6.4 and 6.5, there had been questions on what multiplexing means here and the question was not clear, as this according to moderator understanding also related to mixed SCS / different PUCCH slot length, this is not discussed in the 2nd round. We will come back to it, e.g. next week when having more clarity on the other aspects together with mixed SCS / different PUCCH length handling.

* 1. 4th round of email discussion

**Terminology / SUL issue**

There been objections to all PUCCH carrier switching related proposals earlier by Huawei, due to the unclear terminology / notation. Based on the input to Question 6.5.1, a majority of companies do not see the need to change the currently used notations whereas some companies think it should be changed as also PUCCH carrier switching for SUL is to be supported.

Huawei raised 3 different scenarios:

* **Case 1**: do PUCCH switching among different cells with each cell only configured with NUL
* **Case 2**: do PUCCH switching among different cells with some of the cell(s) configured with both NUL and SUL
* **Case 3**: do PUCCH switching among NUL and SUL of a single cell

As none of this had been discussed so far (and not a single company up to now had brought up anything in their contribution, let’s discuss the support for case 2 and case 3 later on, e.g. in Oct. meeting), the moderator proposes to decouple the discussions (and not prevent us from taking any further agreements before having the SUL issue resolved):

**Proposal : Continue to use the current notation used up Rel-106-e of calling the feature ‘PUCCH carrier switching’ but otherwise using ‘PUCCH cell / target PUCCH cell / PUCCH reference cell’**

* **Note: this does not preclude the support of ‘PUCCH carrier switching’ including SUL in Rel-17**
* **FFS: If ‘PUCCH carrier switching’ involving SUL is to be supported in Rel-17**

|  |  |
| --- | --- |
| Support | Nokia/NSB, DOCOMO, Samsung, Sony, Intel, Panasonic, Apple, ZTE, QC, NEC |
| Object | MediaTek, Huawei/Hisi, Spreadtrum, CMCC |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | We think to agree to support this proposal to be essential. We can decide on the support of Case 2 and Case 3 later and independently, after having received more input on the intended operation by the proponent companies (e.g. in RAN1#106-bis e) |
| Samsung | Should continue to “aim for minimum specification impact”. Once a “cell-based” solution is available, we would support considering to incorporate SUL if that would be a simple extension. |
| Xiaomi | Generally agree with the proposal, but we think Note and FFS part have the similar meaning, it is better to combine them or just remove the FFS. |
| MediaTek | We objecting the proposal because it is not clear to us what is the intention/implication of it. |
| Huawei/Hisi | The main worry from companies is that support of PUCCH switching between NUL and SUL may bring much additional specification efforts. Based on our initial analysis, the additional specification impact is almost zero or at most some additional RRC impact if needed. Take the proposals in section 6.6 as an example, the detailed analysis on potential additional specification impact is shown in the last paragraph. However, we think it is fair to leave people more time to check and think, thus we can compromise to add “with minimum additional specification impact” and meanwhile take it as working assumption.  The other concern from some company is that we are trying to change the agreement. Firstly, we don’t agree with the comment.  We don’t think that we have any agreement to say that PUCCH switching between NUL and SUL is precluded. The current agreements can be interpreted in either this way or that way, that is why we are trying to clarify the supported scenarios here. Secondly, we don’t need to change any previous agreements, since all those are high level principle to support PUCCH carrier switching. On top of those agreements, there is no any problem to continue to support PUCCH switching between NUL and SUL.  Thereby we recommend the proposal is modified as below.  **Proposal : Continue to use the current notation used up Rel-106-e of calling the feature ‘PUCCH carrier switching’~~but otherwise using ‘PUCCH cell / target PUCCH cell / PUCCH reference cell’~~**   * **~~Note: this does not preclude the support of ‘PUCCH carrier switching’ including SUL in Rel-17~~** * **(Working assumption): ~~FFS: If~~ ‘PUCCH carrier switching’ involving SUL is to be supported in Rel-17 with minimum additional specification impact**   **Detailed analysis on the specification impact on proposals in section 6.6:**   * **Modified Proposal 6.1:** No any addition specification impact needed compared to CA case, only need to change cell to carrier in the proposal. Similar as per cell, the current R15/16 mechanism already enable separate P0/TPC configuration for NUL and SUL, separate accumulating closed loop power control for NUL and SUL, and separate TPC command indication using DCI format 2\_2 on NUL and SUL, which means that uniform mechanism can be applied for both CA case and cases involving SUL. * **Modified Proposal 6.3, 6.6:** No any addition specification impact needed compared to CA case, only need to change cell to carrier in the proposal. * **Proposal 6.4/6.5:** No any addition specification impact needed or at most some potential RRC impact if really needed, only need to change cell to carrier in the proposal. These two proposals are related to reference cell, so if SUL configured also the only additional thing is to indicate which carrier to be used as the reference. There is very simple way, for example NUL of the cell can be always used, which is exactly the same as CA case. Or if people want some flexibility, then can use some RRC configuration to configure the carrier to be used as the reference.   **Modified Proposal 6.4.1:** No any addition specification impact needed. |
| LG | We would like to suggest to use same expression for FFS part; “PUCCH carrier switching including SUL” instead of “PUCCH carrier switching’ involving SUL”. If SUL is configured for a cell, it should be supported to switching to the cell is in order to use SUL in the cell. |
| Spreadtrum | The intension of the proposal is not clear to us. We are fine with HW’s update and analyze. |
| QC | We have the same view as in previous round of email discussion. Before RAN1 has new agreement to support dynamic switch between SUL and NUL, we will stick with previous agreement. Therefore, we support this proposal.  In our view, even if this proposal cannot be agreed, by default, RAN1 shall stay with the previous notations agreed in previous agreements and continue to use them. |
| China Telecom | The Note and FFS part have the similar meaning. We agree to add “with minimum additional specification impact” and take it as working assumption. |
| CMCC | Considering the limiting time left for this feature in R17, it is better to take this meeting’s opportunity to clarify the exact impact of supporting SUL carrier switching. Huawei’s modified version looks fine to us if spec impact is the major concern here. |

And to see where companies stand, let’s try to gather companies input on if ‘PUCCH carrier’ switching involving SUL, i.e. including cases 2 and/or 3:

* **Case 1**: do PUCCH switching among different cells with each cell only configured with NUL
* **Case 2**: do PUCCH switching among different cells with some of the cell(s) configured with both NUL and SUL
* **Case 3**: do PUCCH switching among NUL and SUL of a single cell

**Question 6.5.1: For PUCCH carrier switching, should in addition to ‘PUCCH cell switching’ also PUCCH carrier switching involving SUL (i.e. Case 2 and/or Case 3) be supporting in Rel-17?**

|  |  |
| --- | --- |
| Yes | vivo (at least Case 2), Xiaomi, MediaTek, Huawei/Hisi, Panasonic, Spreadtrum, China Telecom, CATT, CMCC |
| No | Samsung, ZTE, QC |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| vivo | We are fine to support at least Case 2 with keeping the legacy concept of only one PUCCH configuration (either on NUL or SUL) per cell even if the cell has NUL and SUL.  About Case 3, we would like to investigate the specification efforts for supporting it. If there is not much complexity from specification perspective, we are open to support Case 3 subject to independent UE capability. |
| Samsung | We are willing to consider support for Case 3 once the “cell-based” design becomes clearer. We don’t support Case 2. |
| MediaTek | Why Case-2 is not considered part of ‘PUCCH cell switching’?  We do not see a need to have agreement to say Case-2 is supported, there is no reason to exclude a cell from PUCCH carrier switching if it is configured with both NUL and SUL.  Case-3 may require some discussion. In our view, this case should be enabled within the general framework for PUCCH carrier switching (in other words, no special optimization for only case-3). |
| Huawei/Hisi | As we mentioned in the last round and the 1st proposal under 6.5, SUL Case 2 and Case 3 should be supported in R17 PUCCH carrier switching. Examples are shown in the figures below.   |  |  | | --- | --- | | Case 2 | Case 3 | |
| Apple | We are open to discuss it further. |
| Spreadtrum | We are fine to include case 2 and case 3 into PUCCH cell switching. The implementation complexity is also acceptable from our point of view. |
| OPPO | We are open to discuss case 2. |
| QC | For the SUL issue, Case 2 and 3 are different.  For case 2, we have a question for clarification, as the current formulation of case 2 is a little unclear. In our understanding, case 2 means that PUCCH is fixed on either SUL or NUL in the cell having both SUL and NUL, but PUCCH can switch to/from to another cell. Can FL clarify if that is correct understanding of case 2?  For case 3, it is dynamic switch between SUL and NUL on a single cell. It was heavily debated in Rel-15 and turns out not supported. We don’t see the need to revisit and support this. Furthermore, support SUL/NUL indication will require an additional bit in DCI or double the RRC configuration for the time pattern, as typically the SUL and NUL will need different time pattern. |
| Nokia/NSB | We are open to discuss Case 2, but as QC mentioned some further clarification would be needed.  On Case 3, we agree that this had been discussed before. Moreover, maybe the proponent companies (e.g. HW) could clarify the benefits of supporting this. What is the motivation here, as the gNB can configure the SUL carrier to carry the PUCCH in the first place so the argument of the TDD impacts would not be there? The argument for the SUL was to allow simultaneous UL/DL operation of a cell and if having the PUCCH configured on SUL for a cell, this should be sufficient.  Overall, we think that further discussions may be needed and would be better if companies prepare their input the next RAN1 meeting and we decide on the support in the next meeting (but agree to the proposal above in this meeting, to continue the specification work otherwise). |
| CATT | We share the same view as vivo. |
| Moderator | Maybe some of the proponent companies (e.g. Huawei) could clarify the intended operation of Case 2 and Case 3 (and the need for supporting them, see some of the comments above), as the cases themselves and the issues was brought up recently by them. |
| Huawei/Hisi2 | **As a clarification for Case 2**, the behaviour of switching for case 2 depends on whether only one carrier (i.e. either NUL or SUL similar as Rel-15/16) is configured with PUCCH transmission (case 2-1), or both NUL and SUL are configured with PUCCH transmission (case 2-2). For case 2-1, PUCCH is fixed at the configured carrier (i.e. either SUL or NUL) and can switch to/from to another cell, as shown in Example 1 in the figure below. For case 2-2, since both SUL and NUL are configured for PUCCH transmission, then PUCCH switching can be done among all the 3 uplink carriers as shown in Example 2.   |  |  | | --- | --- | | Example 1 (case 2-1) | Example 2 (case 2-2) |   **For case 3**, PUCCH switching is not supported in R15 regardless of SUL scenario or UL CA scenario. As we are now enabling PUCCH carrier switching in R17, it is natural to include fairly all scenarios (i.e. SUL scenario and UL CA scenario), and it should not be called as a revisit for SUL scenario.  **For the carrier indication overhead**, it is to be clarified the DCI overhead for Case 3 are not necessarily increased as compared to Case 1 if they have the same number of uplink carriers. As shown in the figure below, for Case 1, two carriers operate in CA mode, and the switching between the two Cells is indicated by 1 bit carrier indicator; for Case 3, two carriers operate in SUL mode, and the switching between SUL and NUL is also indicated by 1 bit carrier indicator. In addition, as the DCI overhead depends on number of the carriers configured for PUCCH switching, gNB will take well trade-off between the overhead and configured candidate PUCCH switching carrier number.   |  |  | | --- | --- | | Case 1 | Case 3 |   As for the RRC configured time pattern, one unified time pattern can be applied just similar as CA case. There is no need to configure two different time patterns for SUL and NUL separately.  **As to the motivation**, the FDD carrier (e.g., 700/800/900/1800/2100, etc.) has UL available on each slot, but typically the bandwidth is smaller than TDD (e.g., C-band) and the neighbouring cell interference is more severe. So TDD carrier, if UL is available, would possibly be a better choice than the FDD carrier in some cases, thus the PUCCH can switch to NUL carrier on the TDD UL slot, and switch to SUL carrier on other slots. We think this is exactly the same case for PUCCH switching between TDD-FDD for the UL CA scenario and even for FDD-FDD for the UL CA scenario. |
| CMCC | Huawei’s explanation above looks reasonable. It is a good design if DCI/RRC indication can be unified with or without SUL. |

**Proposals from 1st round check-up also objected due to other reasons than the Terminology / SUL issue**

On the **supported UCI types for SS-PUCCH carrier switching**, in addition to the notation objection from Huawei, Apple objected as they consider this an optimization which may not be needed. Let’s check after the further discussions the proposal would be acceptable to Apple:

**Proposal 6.8: Semi-static PUCCH carrier switching is applicable to all UCI types incl. HARQ-ACK, SR and CSI.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, NEC, Samsung, CATT, OPPO, CMCC, vivo, China Telecom, ZTE, Mediatek, Huawei (if the notation in Question 6.4.1 goes Alt.2), Lenovo/Motorola Mobility, DOCOMO, FGI/APT,Xiaomi, Intel |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Apple | We are fine with the proposal. |
| QC | We don’t object this proposal. But with this proposal, it could create more scenarios where different UCI types on different CCs. For example, P-CSI is switched on SCC where dynamic A/N is on PCC. In general, these scenarios would need complicated UCI multiplexing procedure to handle (especially with different numerologies). RAN1 should aim to avoid such scenarios by make sure all UCIs use the same PUCCH cell in a given slot.   Moderator. Please note, this proposal is for semi-static PUCCH carrier switching only (i.e. time domain pattern). For this, there is no ‘AN’ on PCC at a certain time and CSI on another CC, as for a slot of the reference cell, there is only a single ‘PUCCH cell’  QC to moderator: Yes, we know this proposal is for semi-static PUCCH carrier switch only. But in a practical system, with this proposal, scenario of two PUCCHs on two different CCs could occur more often than without this proposal, when we considering joint operation of semi-static and dynamic PUCCH switch. But anyway, like we said before, we don’t object this proposal. |
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Intel objected to the following and insists on using PRI instead for dynamic indication. Please take the discussions in the previous round into account:

**Modified Proposal 6.2: For PUCCH carrier switching based on dynamic indication in the DCI, introduce a new, dedicated DCI field for the DCI scheduling PDSCH to indicate the target PUCCH cell.**

* ***~~FFS: Bit-field width for DCI format 1\_1~~***
* **~~DCI field presence for DCI format 1\_2 is independently RRC configured~~**
  + ***~~FFS: Bit-field width for DCI format 1\_2~~***
* ***~~FFS: If some bit(s) from existing bit fields could be used for DCI format 1\_0~~***

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Ericsson (only main bullet), DOCOMO, Samsung, Spreadtrum, QC, NEC, CATT, FGI/APT, Lenovo/Motorola Mobility, Xiaomi, CMCC, China Telecom, Huawei (if the notation in Question 6.4.1 goes Alt.2), MediaTek, ZTE |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Intel | We will not object |
| Panasonic | We do agree that including the carrier index in the PRI is more beneficial. This allows defining different number of PUCCH sets for the carriers. For a dedicated field in DCI for the carrier index, there could be a case that some bit representations are not used. For instance, 2 bits are used for the carrier index field while only 3 carriers are configured. Hence, we also encourage companies to consider the indication of carrier index through the PRI, which brings more functional flexibility.  However, as stated earlier, we are fine with both design options for the sake of progress. |
| Apple | We support the proposal. |
|  |  |
|  |  |

On the reference cell discussion, I keep the proposal here (vivo & CATT, please check the discussions further down on mixed SCS / PUCCH slot length for semi-static PUCCH carrier switching before ‘objecting’ here):

**Mod Proposal 6.7: For semi-static PUCCH carrier switching, the PCell / PScell is used as reference cell.**

* ***Note: the notation of a reference cell may not need to be introduced in the RAN1 specification depending on how the reference cell is to be determined.***

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, Panasonic, Ericsson, DOCOMO, QC, NEC, China Telecom(for K1 interpretation), LG, FGI/APT, Spreadtrum, CMCC, Mediatek, [Samsung], Huawei (if the notation in Question 6.4.1 goes Alt.2) , Spreadtrum,Xiaomi |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| China Telecom | As is said earlier, we support PCell / PScell used as reference cell for k1 interpretation.  According to the discussion in proposal 6.5.5, all companies think the PUCCH carrier switching points should to be aligned with PUCCH slot/sub-slot boundaries of a PUCCH cell. To guarantee it, our first preferred way for time-domain pattern configuration is using a PUCCH cell having the smallest SCS among PUCCH cells as the reference cell for the time-domain pattern.  Otherwise, if using PCell / PScell as reference cell for time-domain pattern, not only gNB needs additional consideration when configuring the time-domain pattern, but also more RRC signalling overhead. Because when PCell/PScell is not the cell having smallest SCS, the granularity of the time-domain pattern is finer for the proposal compared with our preferred way, but the finer granularity is of no use. To guarantee the aligned carrier switching points with slot/sub-slot boundaries of a PUCCH cell with smaller SCS, the same PUCCH carrier should be configured by gNB within a slot/sub-slot of a PUCCH cell with smaller SCS. |
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**Further details on the configuration of the time-domain pattern:**

As several points are now put to FFS in Proposal 6.4, let’s check different options for the time domain pattern configuration. Namely, if the periodicity of the pattern is fixed or if the pattern periodicity is configurable.

**Question 6.5.2: For semi-static PUCCH carrier switching, the time-domain pattern periodicity is**

* **Alt. 1: fixed to 10ms (i.e. fixed to the maximum value of *dl-UL-TransmissionPeriodicity*)**
  + ***Note: shorter periodicities can be created but repeating the shorter pattern within the 10ms pattern***
* **Alt. 2: RRC configured, using candidate values of applicable periodicities from *dl-UL-TransmissionPeriodicity* (i.e. {ms0p5, ms0p625, ms1, ms1p25, ms2, ms2p5, ms5, ms10})** 
  + ***Note: this does not reduce the RRC overhead compared to Alt. 1 due to ASN.1 coding***
* **Alt. 3: Other**

|  |  |
| --- | --- |
| Alt. 1 | Nokia/NSB, DOCOMO, CMCC |
| Alt. 2 | DOCOMO, vivo,Xiaomi, Intel, Huawei/Hisi, Panasonic, Apple, ZTE, NEC, CATT |
| Alt. 3 - other | Samsung, OPPO, China Telecom |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | Alt. 1 for simplicity. As mentioned by moderator this does not limit to operate with smaller intended periodicities. |
| DOCOMO | Either Alt 1 or Alt 2 is OK. |
| vivo | Alt.2 can achieve Alt.1 and more flexible.  For Alt.1, in order to achieve shorter periodicities by repeating the shorter pattern within the 10ms pattern, the RRC overhead will not be saved compared to Alt.2. |
| Samsung | Capture TDD UL-DL configuration period of “reference cell” (PCell/cell with smaller SCS). That is enough and there is no need to define anything else. |
| Xiaomi | Alt 2 is more flexible . |
| Apple | Even though we agree Alt. 1 works, we slightly prefer Alt 2 considering the signaling overhead. |
| OPPO | We share same view as Samsung |
| QC | We think either Alt 1 or 2 should be fine. |
| China Telecom | ms3, ms4 can be configured by dl-UL-TransmissionPeriodicity-v1530. If ms3 is configured for TDD DL UL transmission periodicity, using fixed 10ms for the time-domain pattern periodicity can hardly make time-domain pattern configuration aligned with TDD DL-UL configuration. The RRC configured candidate values of applicable periodicities could also include ms3, ms4. |
| NEC | Alt.2 is slightly preferred for flexibility. |
| CATT | The RRC overhead of Alt. 2 in shorter periodicities is smaller compared with Alt. 1. |
| CMCC | Either Alt 1 or Alt 2 is fine. Prefer Alt 1 for its simplicity, stability, and unity.  Some companies prefer Alt 2 for the overhead advantage. However, this is an RRC signalling, it is not frequently configured. Say, half an hour when users change serving cell? And that’s when users are in connected mode.  *“Simple is better than complex.”, “Readability counts.”*— *the Zen of Python* |

**Different PUCCH slot length handling for dynamic indication of PUCCH carrier switching:**

Please note, that this includes the mixed SCS handling but may be more generic, as based on the PUCCH config there could be a mixture of sub-slot and slot-based PUCCH operation of different carriers for the same PHY priority. E.g. having a combination of 30kHz slot-based PUCCH and 15kHz 7symbols sub-slot based PUCCH would lead to the same PUCCH slot length, even though the SCS of the different PUCCH cells would be different.

Two cases need to be considering, (i) PUCCH slot on PCell is shorter than PUCCH slot on dynamically indicated PUCCH cell and (ii) PUCCH slot on PCell is longer than PUCCH slot on dynamically indicated PUCCH cell.

The problem of (i) PUCCH slot on PCell is longer than PUCCH slot on dynamically indicated PUCCH cell is shown in the Figure below. In the Figures, as we did not agree yet which UCI can be located on the dynamically PUCCH cell, the editor is using so far generic ‘UCI’ there.



The following questions come to mind here:

* Assumption: UCI1 on PCell depending on the decision of Proposal 6.4.1 (see discussion there) may be one or more of SR, CSI and/or SPS HARQ without a corresponding DCI.
* And there is dynamic indication of a PUCCH transmission on PUCCH cell:
  + Do we support dynamic indication of slot #m and slot#m+1 (i.e. more than one PUCCH slot overlapping with PCell PUCCH slot?
    - If so, is the UCI1 (at least HARQ, SR & CSI still for discussion) to be mapped to (a) slot #m (i.e. the first slot), (b) slot#m+1 (i.e. last indicated slot) or (c) slot#m or slot#m+1, depending on the overlap of the PUCCH resource on PCell with the PUCCH cell slot (or even PUCCH resource on PUCCH cell)?
    - The same applies, if there would be more than one PUCCH cell slot indicated overlapping with PCell slot (e.g. in slot#m on PUCCH cell 1, and slot#m+1 with PUCCH cell 2)
  + In case only one overlapping slot is expected to indicated, is (a) the UCI1 (at least HARQ, SR & CSI still or discussion) to be multiplexed together with UCI on PCell

**Question 6.5.3: For PUCCH carrier switching based on dynamic indication, for the case of PCell PUCCH slot length to be longer than the dynamically indicated PUCCH cell slot,**

* **Alt. 1: the UE can be indicated with more than one (non-overlapping) PUCCH slots on one or more PUCCH cells overlapping with a single PCell/PSCell PUCCH slot.** 
  + ***FFS on how to select one of the (non-overlapping) slots on a PUCCH cell for UCI multiplexing from PCell***
* **Alt. 2: the UE is not expected to be indicated with more than one (non-overlapping) PUCCH slots on one or more PUCCH cells overlapping with a single PCell/PSCell PUCCH slot.** 
  + ***The UCI from PCell PUCCH slot (if supported, details still FFS) is multiplexed in the single indicated PUCCH cell slot.***
* **Alt. 3: other**

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| Alt. 1 | DOCOMO (1st preference), vivo, Xiaomi, MediaTek, Intel, Huawei/Hisi (despite the notation), Panasonic, ZTE, Spreadtrum, China Telecom, NEC, CATT |
| Alt. 2 | Nokia/NSB, DOCOMO (2nd preference), vivo, [Samsung], LG, Apple (with FFS on the sub-bullet), OPPO |
| Alt. 3 | Lenovo/Motorola Mobility, QC~~, CATT~~ |

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| --- | --- |
| *Company* | *Comments* |
| Nokia/NSB | Alt. 2 for simplicity, no need to discuss specific rules for this case. |
| DOCOMO | Alt 1. UCI on the PCell slot is mapped to the first dynamically indicated overlapping slot.  Alt 2 can be acceptable as 2nd preference. |
| vivo | Currently, we are open for both Alternatives. Alt.1 has benefits of no scheduling restriction and latency reduction. While Alt.2 is simple. If we cannot converge on solution to achieve Alt.1, then Alt.2 is supported. |
| Samsung | In case of larger SCS for the SCell with the PUCCH, the first overlapping slot is always used – no additional rules or signalling are needed/justified.  For Alt. 2, we do not support the case that configured PUCCH can be transmitted on the PCell (i.e. PCell has valid PUCCH resources) but dynamic PUCCH is indicated to be on the SCell. The SCell should be used only for slots where the UE knows (based on RRC) that there are no available PUCCH resources – otherwise, Rel-16 applies. |
| Xiaomi | Alt 1 is preferred, it has benefit for latency reduction and the success rate of switching. |
| MediaTek | We do not see the need for having scheduling restriction that comes with Alt.2. If the group finds out that Alt.1 introduces high spec impact, we would be fine to go with Alt.1. |
| Intel | Prefer Alt.1 direction to not have the scheduling restrictions |
| Lenovo/Motorola Mobility | We think the figure above is misleading. In Rel-16, there is no UCI in SCell (all UCI is transmitted in PCell or a PUCCH-SCell).  **We propose the following Alt 3:**  “If an UL slot on PCell/PUCCH-SCell overlaps with multiple UL slots on a target PUCCH cell, UE uses the earliest UL slot of the multiple overlapping UL slots of the target PUCCH cell to transmit UCI of the UL slot of PCell/PUCCH-SCell.”  Regarding terminology, we think ‘UL slot’ is more accurate than ‘PUCCH slot’.  **Question 6.5.3: For PUCCH carrier switching based on dynamic indication, for the case of PCell UL ~~PUCCH~~ slot length to be longer than the dynamically indicated PUCCH cell slot,**   * **Alt. 1: the UE can be indicated with more than one (non-overlapping) UL ~~PUCCH~~ slots on one or more PUCCH cells overlapping with a single PCell/PSCell UL ~~PUCCH~~ slot.**    + ***FFS on how to select one of the (non-overlapping) slots on a PUCCH cell for UCI multiplexing from PCell*** * **Alt. 2: the UE is not expected to be indicated with more than one (non-overlapping) UL ~~PUCCH~~ slots on one or more PUCCH cells overlapping with a single PCell/PSCell UL ~~PUCCH~~ slot.**    + ***The UCI from PCell UL ~~PUCCH~~ slot (if supported, details still FFS) is multiplexed in the single indicated PUCCH cell slot.***   **Alt. 3: other** |
| Huawei/Hisi | The 1st overlapped slot can be chosen as the target slot for multiplexing for the latency purpose. |
| Apple | We prefer Alt 2 to avoid the potential jumping of PUCCH on different cells within one PCell slot. We understand in this case rules to select one slot on PUCCH cell many need to defined (if PCell PUCCH is selected as the reference cell and assuming no additional dynamic indication is provided), but we also think it is sufficient.  For Alt 2, we suggest putting FFS on the sub-bullet for now because we would like more time to better understand the implication of cross-carrier UCI multiplexing. Note that there could be multiple PUCCHs in PCell slot, and it is not clear if it is straightforward to support the multiplexing of all the UCIs. |
| QC | We think the formulation of the question can be improved. This question includes two aspects 1) a single PUCCH carrier switch cross CCs with different numerology; 2) UCI multiplexing among CCs with different numerology. We’d like to first understand the intention of this question is to discuss 1) or 2)?  We suggest to put UCI multiplex aside and focus on resolve the simpler problem 1) first. After 1) is resolved, with a clean baseline of single PUCCH behaviour, it will be easier to discuss problem 2) which involves multiple PUCCHs.  For 1), since the PUCCH cell is directly indicated by DCI, we don’t see the overlapping with Pcell matters here. So it seems the question is mainly for problem 2?  But for problem 2), isn’t that we have the stable Mod. Proposal 6.3 already?  **UE does not expect overlapping PUCCH slots with dynamic PUCCH cell indication on more than one carrier, i.e. gNB should only dynamically indicate a single PUCCH cell for a final PUCCH slot.**  In summary, we don’t see the need to discuss this issue for dynamic indicated PUCCH (while for the semi-statically PUCCH or mixed dynamic/semi-static PUCCH, we see the need to discuss). Can FL please clarify?  Moderator: please note that for e.g. CSI or SPS PDSCH without associated DCI there is no dynamic indication of the target PUCCH cell. Proposal 6.3, only covers the case of the dynamic indication to be applicable.  QC to moderator: Thanks moderator for the comment. But this question 6.5.3 itself is “For PUCCH carrier switching based on dynamic indication” only, no? Then it is covered by Proposal 6.3 already. The overlapping scenario described in question 6.5.3 does not exist with proposal 6.3. So the question/proposal seems not needed.  We think this question is needed when we consider joint operation of semi-static and dynamic PUCCH carrier switch. |
| China Telecom | As is agreed for dynamic indication of PUCCH carrier switching, the PDSCH to HARQ-ACK offset k1 is interpreted based on the numerology of the dynamically indicated target PUCCH carrier. Thus the PUCCH slot/sub-slot on the indicated PUCCH carrier can be selected based on the indicated k1. |
| NEC | Alt.1 is preferred since it has no scheduling restriction. |
| CATT | We do not see an issue to indicate more than one PUCCH slots on one SCell overlapping with a single slot on PCell considering that K1 is with reference to the target cell. But if it is allowed to indicate more than one PUCCH slots on more than one SCells overlapping with a single slot on PCell, it may be complicated if we consider different numerologies among the target SCells. Therefore ,our preference is Alt. 3 as follows.   * **Alt. 3: the UE is not expected to be indicated with more than one (non-overlapping) PUCCH slots on ~~one or~~ more PUCCH cells overlapping with a single PCell/PSCell PUCCH slot.**    + ***The UCI from PCell PUCCH slot (if supported, details still FFS) is multiplexed in the single indicated PUCCH cell slot.***   Moderator comment: Don’t get how Alt. 3 is different to Alt. 2. As Alt. 2 includes the option to have more than one cell as well (one or more, includes more right – but there could also be more slots of a single PUCCH cell overlapping). But it seems Alt. 3 would prevent the 2nd case (e.g. 2 slot of a single PUCCH cell overlapping with the PCell)??  [CATT] Thanks FL for your follow-up. We overlooked “non-overlapping” in the proposal. Our preference is Alt. 1 as corrected in the table above. |

Now the other case, the PCell PUCCH slot length to be shorter than the dynamically indicated PUCCH cell slot, as shown in the Figure below:



So, there could be UCI on PCell in two slots (k & k+1) overlapping with the single indicated PUCCH cell. The options here are (i) to either only support UCI from slot k or k+1 but not both or support both, and the UCI is all together multiplex on the SCell. There could be different options and potential restrictions defined, let’s see where companies preferences are:

**Question 6.5.4: For PUCCH carrier switching based on dynamic indication, for the case of PCell PUCCH slot length to be shorter than the dynamically indicated PUCCH cell slot,**

* **Alt. 1: the UE does not expect UCI from more than one PCell PUCCH slot to be overlapping with a single dynamically indicated PUCCH cell slot** 
  + ***Note: in the figure above, only either UCI1 or UCI2 can be present and if applicable can be multiplexed on slot m together with UCI3***
* **Alt. 2: there can be the UCI from more than one PCell PUCCH slot to be overlapping with a single dynamically indicated PUCCH cell slot** 
  + ***Note: in the figure above, applicable UCI1 and UCI2 can be multiplexed on slot m together with UCI3***
* **Alt. 3: other**

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| Alt. 1 | Nokia/NSB, DOCOMO, vivo,Xiaomi, Intel, Huawei/Hisi (despite the notation), LG, Spreadtrum, OPPO, NEC, CMCC(2nd preference) |
| Alt. 2 | Vivo, MediaTek, Panasonic, ZTE, China Telecom, CMCC(1st preference) |
| Alt. 3 | Samsung (we do not support specifying the described scenario), Lenovo/Motorola Mobility, QC, CATT |

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| *Company* | *Comments* |
| Nokia/NSB | Alt. 1 for simplicity, no need to discuss the multiplexing of UCI from more than one PUCCH slot on a single PUCCH SCell slot. |
| DOCOMO | Alt 1.  If more than one PCell slots overlap with one dynamically indicated PUCCH cell slot, multiple HARQ-ACKs on PCell may need to be multiplexed to one indicated PUCCH cell slot. However, multiplexing of different HARQ-ACKs in different slots is different from Rel-15/16 principle. Therefore, we don’t prefer such case. |
| vivo | Similar comments as for Question 6.5.3. |
| Samsung | If the PCell is to be “reference cell”, we do not support the PCell to have larger SCS than the SCell with the PUCCH (one reason is to avoid situations shown in the above figure). Applicability is limited in practice but specification impact is not. |
| Xiaomi | Alt 1 is simple. We think multiplexing on target switching carrier is not expected. |
| MediaTek | Similar view to Question 6.5.3. |
| Lenovo/Motorola Mobility | Agree with Samsung’s comment. Limited applicability.  **We propose the following Alt 3:**  The UE does not expect that SCS of an active UL BWP of a dynamically indicated PUCCH cell is smaller than SCS of an active UL BWP of a PCell/PUCCH-SCell. |
| Huawei/Hisi | We are open to both. If we cannot quickly converge to the detailed design under Alt.2, Alt.1 looks to be the simple way. |
| LG | At least for HARQ-ACK, it would be better to avoid such cases. |
| Apple | Overall we prefer the multiplexing behavior is left for FFS. If multiplexing behavior is defined properly, we could potentially go with Alt 2 (maybe with dropping of some UCIs). That is, it may be ok to allow flexible configuration if simple multiplexing behavior is defined.  We prefer some more time to investigate the multiplexing behavior before making final decision. Note that this may also interact with the ongoing intra-UE multiplexing/prioritization discussion. |
| Spreadtrum | Support Alt.1 for simplicity. If a detailed rule for multiplexing from more than one PUCCHs can be determined, Alt.2 can also be supported. |
| QC | Same comments as for previous question. We don’t see the need to discuss this issue for dynamic PUCCH, because Mod. Proposal 6.3 already resolved the issue. |
| China Telecom | The PUCCH carrier and slot/sub-slot location of a UCI are determined by the DCI indicated PUCCH carrier and K1(reference numerology is the indicated carrier) respectively. If DCI indicates the green PUCCH cell and slot m in the figure, UCI1 and UCI2 naturally have the same cell/slot location as UCI3. |
| NEC | Alt.1 is preferred for simplicity. |
| CATT | Which type of UCI are we talking about? In addition, are we talking about same UCI type in multiple Pcell slots or not? |
| CMCC | Alt 2 is preferred because this might be the real case: When UCI is switched from Pcell to PUCCH cell because PUCCH cell is on UL direction, PUCCH cell might be receiving UCIs from more than 1 Pcell slot and yet there is only 1 UL slot on PUCCH cell.  Alt 1 is acceptable as a compromise if too much specification effort is required. |

**Different PUCCH slot length handling for semi-static PUCCH carrier switching:**

Please note, that this includes the mixed SCS handling but may be more generic, as based on the PUCCH config there could be a mixture of sub-slot and slot-based PUCCH operation of different carriers for the same PHY priority. E.g. having a combination of 15kHz slot-based PUCCH on PCell / reference cell (e.g. PCell) and 30kHz 7symbols sub-slot based PUCCH on the target PUCCH cell would lead to the same PUCCH slot length, even though the SCS of the different PUCCH cells would be different.

Two cases need to be considering,

* Slot length of the time-domain pattern is shorter than the PUCCH cell slot
  + This case may not be applicable, e.g. if the reference cell has the smallest SCS when using the same slot or sub-slot based PUCCH configuration on the PUCCH cells.
* Slot length of the time-domain pattern is longer than the PUCCH cell slot
  + This case may not be applicable, e.g. if the reference cell is the largest SCS when using the same slot or sub-slot based PUCCH configuration on the PUCCH cells.

For the case, the **slot of the time-domain pattern /reference cell is shorter than the PUCCH cell slot**, Nokia raises the issue that this could lead to situations, that the time-domain pattern may indicate a PUCCH carrier switching in the middle of a PUCCH slot, as shown in the following Figure:



In this example, gNB indicates the pattern {0,1,1,1}, which leads to the case that slot#m of cell 0 is determined for the 1st reference cell slot, but for the 2nd reference cell slot cell 1 is indicated resulting in slot k on Cell 1. But please note, that slot #m on cell 0 is overlapping with slot k on Cell 1, which would clearly complicate the operation. Therefore, Nokia proposed that gNB should prevent such ambiguous cases that would need extensive specification handling by requiring the gNB to prevent such cases due to proper time-domain pattern configuration.

**Proposal 6.5.5: The gNB will need to guarantee by configuration of the time-domain pattern for PUCCH carrier switching, that the PUCCH carrier switching points are to be aligned with PUCCH slot/sub-slot boundaries of a PUCCH cell.**

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| Support | Nokia/NSB, DOCOMO, vivo, Samsung, Xiaomi, Intel, Lenovo/Motorola Mobility, Huawei/Hisi (despite the notation), LG, Apple, ZTE, Spreadtrum, OPPO, China Telecom, NEC, CATT, CMCC |
| No – do not support | QC |

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| *Company* | *Comments* |
| vivo | If the reference numerology used for time-domain pattern for PUCCH carrier switching is defined as the smallest SCS among PUCCH cells, then proposal 6.5.5 is not needed since naturally the PUCCH carrier switching points are aligned with PUCCH slot/sub-slot boundaries of a PUCCH cell. |
| Apple | We support it in principle. It may be better to formulate it from UE perspective, using “the UE is not expected…” or “the UE expects”.  Also agree with vivo’s comments. |
| ZTE | If the reference cell can be RRC configured, the issue will not be a problem. |
| QC | We don’t see any problem to allow the scenario in the below figure that FL provided. Suppose cell 0 is the reference cell. If based on K1, PUCCH transmits in slot m on the reference cell, UE will use cell 0 to transmit PUCCH based on the patter. If based on K1, PUCCH transmit on slot m+1 on the reference cell, UE then switch to cell 1 based on the time pattern. On cell 1, there is only a single slot k which overlap with slot m+1, UE just transmit PUCCH use slot k on cell 1. There is no ambiguity in the mapping/switch from cell 0 to cell 1. We don’t see the need to introduce such a restriction in spec.    Moderator: Please note, that there could be then an overlap of the PUCCH resource in slot m of cell 0 and slot k of slot 1. Is then the UE required to multiplex or not? The intention of this proposal is to reduce specification and implementation effort, i.e. there could not be more than one PUCCH cell active at a time – no need for special handling  QC to moderator: Thanks moderator for the clarification. We see the intention now. As a UE vendor, of course we are not against spec/implementation simplification. So we withdraw our objection. |
| China Telecom | Support for simple specification handling.  For easier handling by gNB to guarantee the aligned carrier switching points by configuration of the time-domain pattern, using an RRC configured PUCCH cell having the smallest SCS among PUCCH cells as the reference cell for the time-domain pattern has the merit to avoid the concerned case. |

But as for dynamic indication, there could be more then one PUCCH cell target slot be overlapping with a single PUCCH slot of the reference cell. Again, the following figure shows the problem:



The same options as for dynamic repetition apply here, so a similar question is brought forward:

**Question 6.5.6: For PUCCH carrier switching based on semi-static operation, for the case the reference cell slot to be shorter than the target PUCCH cell slot,**

* **Alt. 1: the UE does not expect UCI from more than one reference cell slot to be overlapping with a single target PUCCH cell slot** 
  + ***Note: in the figure above, only either UCI1 or UCI2 can be present and if applicable will be transmitted in slot #m on the target PUCCH cell***
* **Alt. 2: there can be the UCI from more than one reference PUCCH slot to be overlapping with a single target PUCCH cell slot** 
  + ***Note: in the figure above, applicable UCI1 and UCI2 can be multiplexed to be transmitted in slot m of the target PUCCH cell***
* **Alt. 3: other**

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| --- | --- |
| Alt. 1 | Nokia/NSB, DOCOMO, vivo, Xiaomi, Intel, Huawei/Hisi (despite the notation) , Spreadtrum, OPPO |
| Alt. 2 | Vivo, Panasonic, ZTE, China Telecom, CMCC |
| Alt. 3 - other | Samsung (we do not support specifying the described scenario), Lenovo/Motorola Mobility,  QC (we don’t agree specifying such an overlapping scenario), CATT |

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| *Company* | *Comments* |
| Nokia/NSB | Alt. 1 for simplicity, as for dynamic indication. |
| DOCOMO | Alt 1.  Similar comment as Question 6.5.4. |
| vivo | Similar comments as for PUCCH carrier switching based on dynamic indication. We are open for both Alternatives. |
| Xiaomi | Alt 1 is simple. We think multiplexing on target switching carrier is not expected. |
| Lenovo/Motorola Mobility | Do not support this scenario (this scenario can be avoided with proper determination of reference cell). |
| Huawei/Hisi | Same logic as Question 6.5.4, if both semi-static time pattern and dynamic indication are enabled. |
| LG | Alt. 1 is simple but it has an impact on scheduling flexibility. For semi-static pattern, the issue is hard to be avoided. We are open to discuss both alt. 1 and alt. 2 |
| Apple | We think we should discuss whether the reference cell should be the cell with the smallest SCS so that such a case does not occur.  If we allow such a case, Alt 1 is the preferred way. |
| QC | In general, UCI multiplexing cross CCs (especially with different numerologies) is super complicated. Therefore, we suggest RAN1 to take the similar solution as Mod. Proposal 6.3 – meaning don’t specify UE behaviour for UCI overlapping cross CCs. By the way, this should be the natural outcome anyway, since all the semi-static PUCCH should follow the same time pattern. As long as the dynamic PUCCH is not pointing to a different CC than semi-static PUCCH, there is no cross CC PUCCH overlapping to begin with.  Moderator: Note, this is for semi-static PUCCH carrier switching, there is no dynamic PUCCH cell indication present here.  QC to moderator: With only semi-static PUCCH switch, if we agree on proposal 6.5.5, do we still see this overlapping scenario can happen? I think not. In order words, with Proposal 6.5.5, this proposal/question is not needed.  We think this question is needed when we consider joint operation of semi-static and dynamic PUCCH carrier switch. |
| China Telecom | We assume the reference cell here as the reference cell for K1 to determine the PUCCH slot/sub-slot. If UCI1 UCI2 multiplexing to be transmitted in a slot of the target PUCCH cell is supported for the dynamic indication case, it can be also supported for this case. |
| NEC | Alt.1 is simple but restrictive. So we are open to discuss Alt.1 and Alt.2. |
| CATT | We think it depends on UCI type. |
| CMCC | Same consideration as 6.5.4 |

For the case, the **slot of the time-domain pattern /reference cell is longer than the PUCCH cell slot**, the question arises which of the overlapping target PUCCH cell slots is used for transmission, as shown in the Figure below:



Different options have been suggested for handling this, so let’s just try to get feedback on the options in the input contributions here.

**Question 6.5.7: For PUCCH carrier switching based on semi-static operation, for the case the reference cell slot to be longer than the target PUCCH cell slot (i.e. multiple target PUCCH cell slots overlapping with a single reference cell slot), the following PUCCH cell slot is used for UCI transmission:**

* **Alt. 1: the first target PUCCH slot overlapping with the reference cell slot**
* **Alt. 2: the last target PUCCH slot overlapping with the reference cell slot**
* **Alt. 3: the first (or last) PUCCH slot overlapping with the PUCCH resource determined at the reference cell**
  + ***Note: this requires the UE to in addition perform PUCCH resource determination for the reference cell (additional UE complexity)***
* **Alt. 4: using a relative slot-offset within the reference cell slot indicated by the HARQ-feedback indicator in the DCI**
  + ***Note: the offset can be dynamically indicated for each reference cell slot, details see Nokia [3]***
* **Alt. 5: using a relative slot-offset within the reference cell slot, the relative slot offset is configured in the time domain pattern (i.e. time domain pattern contains ‘cell index’ & ‘slot\_offset’ for each reference cell slot)**
  + ***Note: different relative slot offset can be configured for each reference cell slot in the time domain pattern, details see Ericsson [4]***
* **Alt. 6: using a relative slot-offset configured per target PUCCH cell within the reference cell slot** 
  + ***Note: see details in Panasonic [10], only a single relative slot-offset is applicable per PUCCH cell – in contrast to Alt. 5, where for the same target PUCCH cell a different slot-offset can be configured per reference cell slot***
* **Alt. 7: other**

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| Alt. 1 | DOCOMO, vivo, Samsung, Xiaomi(2 perference), Lenovo/Motorola Mobility, Huawei/Hisi (despite the notation), LG (2nd preference) , Spreadtrum, OPPO, QC, NEC, CATT, CMCC(2nd preference) |
| Alt. 2 |  |
| Alt. 3 | v |
| Alt. 4 | Nokia/NSB (1st preference) |
| Alt. 5 | Nokia/NSB (2nd preference), Xiaomi(1st preference), Panasonic, ZTE |
| Alt. 6 | Panasonic |
| Alt. 7 - Other | CMCC(1st preference) |

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| *Company* | *Comments* |
| Nokia/NSB | As discussed in our contribution, having a fixed mapping to the first slot may not be a good decision. We prefer the dynamic indication as to Alt. 4, but could be also fine with Alt. 5 (having less flexibility compared to Alt. 4, but still better than some fixed mapping). |
| DOCOMO | Alt 1.  Latency is the main motivation for PUCCH carrier switching. The first overlapping slot can result in smallest latency. Moreover, it is simpler than Alt 4/5/6 using “slot\_offset”. Alt 1 is more robust than Alt 4 which depends on the PUCCH resource selection. |
| vivo | We prefer Alt.1 for simplicity. Similar as SPS deferral, load balancing is not pursuit. |
| Samsung | In case of larger SCS for the SCell with the PUCCH, the first overlapping slot of the SCell is always used – no additional specification impact (rules or signalling) are needed/justified. |
| Huawei/Hisi | For the latency purpose it is simple to go on the 1st overlapping slot. Note that the load balancing for PUCCH is not as essential as for data channel with respect to the much smaller resources occupied by PUCCH. |
| LG | Alt 1 or Alt 3 can be used in straightforwardly, even when sub-slot is configured |
| Apple | Our initial preference is Alt 2. Even though it does not have all the flexibility, we think it is sufficient to achieve the benefit of the feature (i.e. PUCCH can be transmitted in the same reference cell slot).  The concern with Alt 1 is that the first target PUCCH slot may be too early for HARQ-ACK feedback, which would cause the delay into the next reference cell slot. In addition, the first target PUCCH slot would not work in a DL/UL switching slot because it is typically DL.  Alt 5/6 may be considered further if the benefit is identified. |
| QC | Using the first slot is aligned with the design principle of PUCCH cell swich, which is to reduce the latency for PUCCH. |
| China Telecom | We assume the reference cell here as the reference cell for K1 to determine the PUCCH slot/sub-slot and are open to Alt1 1, Alt 2, Alt 4. |
| NEC | Alt.1 is preferred for simplicity. |
| CATT | We prefer Alt. 1 for simplicity. Moreover, we are open to discuss whether to defer to the next slot if the PUCCH resource in the first slot is not available as what is done for PUCCH repetition. |
| CMCC | Alt. 1 is ok, but isn’t it easier if we can only take care one condition among two (1. reference slot is longer, 2. Reference slot is shorter) ?  For example, if we require reference slot as the longest or shortest one. Then we can only worry about 1 problem. |

* 1. 5th round of email discussion

**5th Round updates: Please note, only the PUCCH cell / carrier and SUL issues is updated / expanded in 5th round, if not done yet, please keep commenting on the other issues in the 4th round in Sec. 6.5.**

**Terminology / SUL issue**

On the proposal discussed in the GTW session, there were not really comments except that if we could have a working assumption on the support of SUL agreed. Companies, please check the discussions in the previous section on this issue, including the explanation of the scenarios by Huawei.

Let’s see if we can agree a working assumption in this meeting on the support of PUCCH carrier switching including NUL and SUL carriers.

**Proposed working assumption: For PUCCH carrier switching, the following switching scenarios are supported in Rel-17:**

* **Case 1: PUCCH carrier switching among different cells not being configured with SUL**
* **Case 2-1: PUCCH carrier switching among different cells where at least one cell is configured with SUL. For the cells having SUL configured, PUCCH is only configured either for NUL or SUL.**
* **Case 2-2: PUCCH carrier switching among different cells where at least one cell is configured with SUL. For cells having SUL configured, PUCCH may be configured for NUL carrier, SUL carrier or both**
* **Case 3: PUCCH carrier switching for a single cell configured with SUL and having PUCCH configured for NUL and SUL**

|  |  |
| --- | --- |
| Support | ~~Nokia/NSB,~~ DOCOMO, CATT, vivo, CMCC, Spreadtrum,Xiaomi, China Telecom, Huawei/Hisi, Panasonic, MediaTek |
| Object | Samsung, QC, Nokia/NSB, ZTE, Ericsson, Apple |

|  |  |
| --- | --- |
| *Company* | *Comments* |
| Samsung | Do not support cases 2-1/2-2. OK with case 3 (and case 1).  There is no identified use-case for the Case 2 or, in general, for having PUCCH on >2 cells/carriers. |
| QC | These cases need to be discussed separately.  Case 1 has nothing to do with SUL, and it is supported anyway.  Case 2-1 is related to SUL. Although we don’t prefer to support SUL with carrier switch, we can compromise to accept case 2-1.  Case 2-2 is not a valid case based on today’s spec. Taking PUCCH switch out of the picture, UE is not allowed to configure PUCCH on both SUL and NUL. Current spec only allow PUCCH on either SUL or NUL. So case 2-2 is not acceptable to us.  For Case 3, as we commented in previous round of email discussion, it is not acceptable to us. Please refer to the rationale we provided in previous round.  To Huawei: regarding the additional 1 bit in DCI, the example Huawei provided is not apple-to-apple comparison. Case 1 supports 2 cells, while case 3 only support 1 cell. With the same number of cells, adding support of dynamic switch between SUL and NUL in a cell definitely requires additional bits in DCI.   |  |  | | --- | --- | | Case 1 | Case 3 | |
| CMCC | SUL is already in use in live network and the best situation is to have a total freedom to configure any carrier/cell for PUCCH.  Because we deploy CA in some places and deploy SUL in some other places, e.g. when UL is needed more. |
| Nokia/NSB | Similar views as QC, cell switching (Case 2-1) could be supported but within the cell having a fixed ‘PUCCH carrier’ (SUL or NUL).  But not Case 2-2 and Case 3. Based on the arguments by Huawei from the 4th round table, we don’t understand why the switching there would be needed. If there is an FDD carrier (as noted by Huawei), why not using this carrier for that cell all the time. The main motivation has been TDD and different UL/DL configurations across serving cells in different bands. But when having an FDD carrier possible to carrier PUCCH continuously, the motivation for the support is still unclear to us. |
| ZTE | Case 3 and 2-2 are not acceptable. |
| Huawei/Hisi | **To QC**  For the Case 2-2 and Case 3, as we mentioned in the last round, **current spec only allow PUCCH on PCell/PSCell for UL CA case**. If we stick to the current spec, there is no base to do PUCCH carrier switching for any scenario now.  For the overhead comparison, how does it matter for the cell number? The carrier switching performance is decided by the UL carrier number, so it is fair to align the same number of UL carriers as they provide the same amount of UL resources.  **To Nokia**  As we explained before, from motivation perspective, case 3 is exactly the same as case 1 with switching between FDD vs TDD, and between FDD vs FDD. The main motivation is to support load balancing, especially usually the bandwidth for SUL or FDD is smaller, and thus load balancing is more beneficial. By the way, the motivation for supporting PUCCH carrier switching is never limited to only latency perspective, but also reliability which can be achieved by flexible PUCCH offloading among different carriers depending on the channel quality and/or interference on different carriers. |
| Lenovo/Motorola Mobility | We support Cases 1 and 3.  If a legacy PUCCH-cell (e.g. PCell, PUCCH-SCell) is configured with SUL, dynamic switching between NUL and SUL would be good enough for latency reduction, in case a TDD carrier is configured as a PUCCH carrier for load balancing between the TDD carrier and the FDD UL carrier.  If the legacy PUCCH-cell is configured with only one UL carrier, switching across cells would be necessary to reduce HARQ-ACK dropping. |
| MediaTek | At least Case-1 and Case-2-1 should be supported. |
| Apple | We do not think case 1 needs to be included in the proposal. Case 1 is supported by default, and the discussion should focus on case 2-1/2-3/3.  It seems that case 2-1 can be supported without much additional effort, so we are fine to support it.  For case 2-2 and case 3, we are not sure yet about the potential spec impact. If it can be supported with minimum spec impact also, we would be open to discuss further. But we prefer some more time for investigation. |

* 1. Stable proposals from earlier rounds subject to notation discussion

The proposals in this section are not up for discussion, as there seemed to be consensus pending the notation discussion. They are just copied here to have them ready when having the notation issue solved:

Based no addition discussions, the FFS on the DCI format 2\_2 usage seem to be fine. So the separate TPC command as being FFS is to be removed (in yellow below).

**Mod. Proposal 6.1: For PUCCH carrier switching, support independent TPC per PUCCH cell including**

* **Separate P0 / TPC configuration per PUCCH cell**
  + ***Note: This flexibility is already provided as PUCCH-config is per UL BWP of a PUCCH cell***
* **Accumulating closed loop power control commands only within the same target cell by reusing Rel-15 procedure, i.e.** 
  + **For dynamic PUCCH cell indication, the TPC command in the DCI scheduling the PUCCH only applies for the dynamically indicated PUCCH target cell**
  + **For semi-static / time-domain pattern, the TPC command in the DCI scheduling the PUCCH only applies for the determined PUCCH target (using the time-domain pattern)**
* **~~FFS:~~ Separate TPC command indication using DCI format 2\_2 for the individual PUCCH cells**
  + ***Note: this requires configuration of individual TPC command starting points for each PUCCH cell within DCI format 2\_2***

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, NEC, QC, Samsung, LG, CATT, vivo, ZTE, Intel, Mediatek, [Samsung], Huawei (if the notation in 6.4.1 goes Alt.2), DOCOMO,XIAOMI, Apple, Ericsson |
| Objecting companies |  |

**Mod. Proposal 6.3: UE does not expect overlapping PUCCH slots with dynamic PUCCH cell indication on more than one carrier, i.e. gNB should only dynamically indicate a single PUCCH cell for a final PUCCH slot.**

|  |  |
| --- | --- |
| Supporting companies | OPPO, vivo, Panasonic, ZTE, DOCOMO, Spreadtrum, QC,NEC, CATT, China Telecom, Ericsson, Samsung, LG, Intel, Mediatek, FGI/APT, Huawei (if the notation in Question 6.4.1 goes Alt.2), Lenovo/Motorola Mobility, Spreadtrum, CMCC,XIAOMI, Apple |
| Objecting companies |  |

**Mod3 Proposal 6.4: For semi-static PUCCH carrier switching, the time-domain pattern configuration is based on the following properties:**

* **A single time-domain pattern is configured per PUCCH cell group**
* **The granularity of the time-domain pattern is one slot of the ~~reference numerology /~~ reference cell**
  + ***~~FFS definition of reference numerology / reference cell~~***
  + ***FFS: how to determine the reference cell***
  + ***Note: the notation of a reference cell may not need to be introduced in the RAN1 specification depending on how the reference cell is to be determined.***
* **The ~~length of the~~ time-domain pattern is applied periodically ~~one frame (i.e. 10ms)~~**
  + FFS on period / pattern length (e.g. 10ms, RRC configured,…).
* **The pattern defines for each slot of the ~~reference numerology /~~ reference cell at least the applicable PUCCH cell**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, NEC, QC, LG, CATT, OPPO, CMCC, vivo, China Telecom, ZTE, Intel, Mediatek, FGI/APT, [Samsung], Huawei (if the notation in Question 6.4.1 goes Alt.2), Lenovo/Motorola Mobility, DOCOMO, Spreadtrum, Xiaomi, Apple, Ericsson |
| Objecting companies |  |

**Mod. Proposal 6.5: For semi-static PUCCH carrier switching, the PDSCH to HARQ-ACK offset k1 is interpreted based on the numerology and PUCCH configuration of a reference cell to be able to apply the time-domain PUCCH carrier switching pattern.**

* + ***~~FFS definition of reference cell~~***
  + ***FFS: how to determine the reference cell***
  + ***Note: the notation of a reference cell may not need to be introduced in the RAN1 specification depending on how the reference cell is to be determined.***

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, ZTE, DOCOMO, QC, NEC, CATT, China Telecom, FGI/APT, LG, [Samsung], Intel, Mediatek, Huawei (if the notation in Question 6.4.1 goes Alt.2) , Spreadtrum, CMCC，Xiaomi, Apple |
| Objecting companies |  |

**Proposal 6.6: For semi-static PUCCH carrier switching, the PUCCH resource indicator (PRI) is interpreted based on the PUCCH configuration of determined target PUCCH cell.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, OPPO, vivo, Panasonic, Ericsson, ZTE, DOCOMO, QC, NEC, CATT, China Telecom, FGI/APT, LG, Lenovo/Motorola Mobility, Samsung, Intel, Mediatek, Huawei (if the notation in Question 6.4.1 goes Alt.2) , Spreadtrum, CMCC, Xiaomi, Apple |
| Objecting companies |  |

**Modified Proposal 6.4.1: In addition to HARQ-Ack of PDSCH dynamically scheduled by a DCI indicating a PUCCH carrier, the dynamic target carrier indication also applies to:**

* **HARQ-ACK corresponding to the first SPS PDSCH activated by Activation DCI based on the indication in the activation DCI**
* **HARQ-ACK corresponding to the SPS Release DCI based on the indication in the release DCI**
* **triggered PUCCH for Rel-16 Type 3 CB, Rel-17 enh. Type 3 CB of smaller size and Rel-17 one-shot triggering for HARQ-Ack retransmission based on the indication in the triggering DCI**
* ***FFS: additional cases***

|  |  |
| --- | --- |
| Supporting companies | NEC, QC, Samsung, DOCOMO, LG, CATT ~~(with changes)~~, OPPO, vivo, ZTE, Huawei, Mediatek, Nokia/NSB, FGI/APT, , Spreadtrum, Intel, Xiaomi, Apple, Ericsson |
| Objecting companies |  |

# Other proposals (not directly related to Sec. 2-6 / agreed Rel-17 HARQ enhancements)

* Increase the number of reserved REs for HARQ-ACK on PUSCH: Samsung [8] (see details in Sec. 2.7 of [8])
* Remove duplicated HARQ-ACK information from the Type-1 HARQ-ACK codebook for intra slot PDSCH repetition: Samsung [8] (see details in Sec. 2.8 of [8])
* The HARQ-ACK timing indicator counts only slots with PUCCH resources: Samsung [8] (see details in Sec. 2.9 of [8])

# References

1. R1-2106490 UE feedback enhancements for HARQ-ACK Huawei, HiSilicon
2. R1-2106586 HARQ-ACK enhancements for Rel-17 URLLC vivo
3. R1-2106636 HARQ-ACK Feedback Enhancements for URLLC/IIoT Nokia, Nokia Shanghai Bell
4. R1-2106678 HARQ-ACK Enhancements for IIoT/URLLC Ericsson
5. R1-2106697 Discussion on HARQ-ACK feedback enhancements for Rel-17 URLLC Spreadtrum Communications
6. R1-2106734 Discussion on HARQ-ACK enhancements for eURLLC ZTE
7. R1-2106801 Considerations on HARQ-ACK enhancements for URLLC Sony
8. R1-2106879 On HARQ-ACK reporting enhancements Samsung
9. R1-2106962 UE feedback enhancements for HARQ-ACK CATT
10. R1-2107025 Discussion on UE feedback enhancements for HARQ-ACK Panasonic
11. R1-2107133 Discussion on UE feedback enhancements for HARQ-ACK China Telecom
12. R1-2107156 UE feedback enhancements for HARQ-ACK NEC
13. R1-2107180 HARQ-ACK feedback enhancement for IIoT/URLLC Lenovo, Motorola Mobility
14. R1-2107272 HARQ-ACK enhancements for Rel-17 URLLC/IIoT OPPO
15. R1-2107296 Discussion on UE feedback enhancements for HARQ-ACK FGI, Asia Pacific Telecom
16. R1-2107336 HARQ-ACK enhancement for IOT and URLLC Qualcomm Incorporated
17. R1-2107397 Discussion on UE feeback enhancements for HARQ-ACK CMCC
18. R1-2107443 Discussion on UE feedback enhancement for HARQ-ACK LG Electronics
19. R1-2107472 UE feedback enhancements for HARQ-ACK ETRI
20. R1-2107491 On UE feedback enhancements for HARQ-ACK MediaTek Inc.
21. R1-2107583 Design aspects for the agreed HARQ feedback enhancements Intel Corporation
22. R1-2107639 HARQ enhancements for IIoT and URLLC InterDigital, Inc.
23. R1-2107732 HARQ Feedback Enhancements for URLLC Apple
24. R1-2107791 UE feedback enhancements for HARQ-ACK Sharp
25. R1-2107833 UE feedback enhancements for HARQ-ACK TCL Communication Ltd.
26. R1-2107851 Discussion on HARQ-ACK feedback enhancements for Rel.17 URLLC NTT DOCOMO, INC.
27. R1-2107917 UE feedback enhancements for HARQ-ACK Xiaomi
28. R1-2108152 Discussion on HARQ-ACK enhancement for URLLC/IIoT WILUS Inc.
29. R1-2108162 UE feedback enhancements for HARQ-ACK CAICT

# Appendix A: RAN1 agreements on HARQ-ACK feedback enhancements for NR Rel-17 URLLC/IIoT

**RAN1#102-e (Aug. 2020)**

Agreements:

Support Rel-17 enhancements to avoid SPS HARQ-ACK dropping for TDD due to PUCCH collision with at least one DL or flexible symbol.

* This topic is to be considered as high priority
* FFS detailed solution(s)

Agreements:

* Simultaneous PUSCH / PUCCH within a cell group (of Sec. 6.13 of R1-2007216) and enhanced (sub-slot) HARQ-ACK multiplexing on PUSCH (of Sec. 4.3 of R1-2007216) can be further discussed as part of AI 8.3.3 in this WI (but not as part of AI 8.3.1.1).

Agreements:

Study further at least the following schemes:

* SPS HARQ skipping for ‘skipped’ SPS PDSCH
* PUCCH repetition enhancements (at least for HARQ-ACK), e.g., sub-slot based, etc.
* Retransmission of cancelled HARQ
* SPS HARQ payload size reduction and / or skipping for ‘non-skipped’SPS PDSCH
* Type 1 HARQ codebook based on sub-slot PUCCH config
* PUCCH carrier switching for HARQ feedback

**RAN1#103-e (Oct/Nov. 2020)**

Agreements: To address the issue of SPS HARQ-ACK dropping for TDD systems, focus on the following two options:

* Option 1: Deferring HARQ-ACK until a next (e.g., first) available PUCCH
  + FFS: Details including the definition of a next (e.g, first) available PUCCH, CB construction / multiplexing
* Option 2: Dynamic triggering of a one-shot / Type-3 CB type of re-transmission
  + FFS: Details on triggering and/or CB construction (incl. potential Type-3 CB optimizations) / multiplexing

**Agreements: In the studies on PUCCH carrier switching for HARQ-ACK, PUCCH carrier switching for different cells operated is considered only for cells that are part of the active UL CA configuration.**

**Agreements: For the studies on SPS HARQ skipping for skipped SPS PDSCH, the further discussions should focus on the following reduced sets methods:**

* **‘NACK skipping’ for (skipped) SPS PDSCH (Alt. 1)**
  + **FFS: details including at least when to skip the HARQ-ACK as well as NACK skipping configuration details (per SPS or group of SPS configurations etc.)**
  + Note: this alternative assumes inherently no identification of a skipped SPS PDSCH by the UE
* **Dynamic indication of skipped SPS PDSCH occasions (Alt. 3)**
  + **FFS: details including dynamic indication methods such as e.g. DCI, MAC CE, specific DM-RS instead of SPS DM-RS, …**

**Agreements:** For the studies on SPS HARQ payload size reduction (of non-skipped SPS PDSCH), the further discussions should focus on the following reduced sets of methods:

1. ACK skipping (NACK-only) (Alt. 1)
   1. FFS: Details
2. NACK skipping (ACK-only) (Alt. 2)
   1. FFS: Details
3. HARQ bundling / compression (Alt. 3)
   1. FFS: Details including HARQ bundling / compression window, bundling / compression technique
4. HARQ-ACK disabling /skipping for certain SPS configurations (Alt. 4)
   1. The skipping / disabling is higher-layer configured per SPS configuration
   2. FFS: HARQ-ACK skipping behaviour for Type 1 CB

**RAN#89 (Dec. 2020) – see agreed conclusion from** [RP-202872](http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_90e/Docs/RP-202872.zip)

**RAN conclusion on IIoT scope:**

* For handling of the PUCCH repetitions it is proposed to proceed as follows:

1. RAN1 to continue discussion on PUCCH repetition, whether to specify or not, in the IIoT/URLLC WI for single TRP.
   1. The following items are not within scope of the continued discussions in the IIoT/URLLC WI:
      1. DMRS-less PUCCH with UCI payload up to 11 bits
      2. PUSCH-repetition-Type-B like PUCCH repetition
      3. DMRS bundling across PUCCH repetitions
2. PUCCH repetition issues with multi-TRP to be handled in Fe-MIMO WI.

* For the UE CSI/HARQ-ACK feedback enhancements in the IIoT/URLLC WI, RAN1 work to continue the discussions. Status to be checked in March if any RAN level guidance needed.
  + RAN1 to continue discussion on A-CSI on PUCCH, whether to specify or not.

**RAN1#104-e (Jan/Feb. 2021)**

Agreements:

* Support deferring SPS HARQ-ACK dropped due to TDD specific collisions until a next available PUCCH in Rel-17 based on semi-static configuration of slot format
  + FFS: Details (including possible conditions for such a deferring, whether or not to consider semi-statically configured flexible symbols for PUCCH availability, etc.)
  + Aim for minimal standardization efforts and UE complexity in implementation

Agreements:

Further down-select between the following two options for SPS HARQ-ACK deferral:

* Option 1: Joint RRC configuration of the SPS HARQ-ACK deferral per PUCCH cell group
  + *Note: any SPS HARQ-ACK within a PUCCH cell group in principle is subject to deferral*
* Option 2: The SPS HARQ-ACK deferral is configured per SPS configuration
  + *Note: part of sps-config, only HARQ-ACK of SPS PDSCH configurations configured for deferral is in principle subject to deferral*

Agreements: Support sub-slot based PUCCH repetition for HARQ-ACK based on the Rel-16 PUCCH procedure for slot-based PUCCH applied to sub-slot based PUCCH

* Note: the intention is to take the Rel-16 slot-based PUCCH by replacing with “sub-slot” appropriately, without further optimization unless necessary
* FFS whether or not there is any restriction for the applicability of sub-slot based PUCCH repetition for HARQ-ACK
* Dynamic repetition indication is supported also for sub-slot based PUCCH in Rel-17
  + FFS: if the method to be specified in Cov. Enh WI for slot-based PUCCH repetition can be directly applied to sub-slot PUCCH or if changes are needed

Agreements: Support PUCCH repetition for PUCCH formats 0 and 2 at least for sub-slot based PUCCH repetition.

* FFS: Support for slot-based PUCCH repetition

Agreements: Rel-16 UCI multiplexing  / PUCCH overriding rules are reused for deferred SPS HARQ-ACK in the target slot, if applicable.

Agreements: For SPS HARQ-ACK, the deferral from the initial slot/sub-slot determined by *k1* in the activation DCI to the target slot/sub-slot determined by *k1*+ *k1def*, the UE will check the validity of a target slot/sub-slot evaluating from one slot/sub-slot to the next sub/sub-slot (i.e. in principle *k1def* granularity is 1 slot/sub-slot)

* FFS: if there is a limit on the minimum deferral considered the required UE processing (*k1def* ≥0)
* FFS: if there is a limit on the maximum deferral

Agreements: For SPS HARQ-ACK deferral, for the determination of valid symbols in the initial slot/sub-slot a collision with semi-static DL symbols, SSB and CORESET#0 is regarded as ‘invalid’ or ‘no symbols for UL transmission’.

Agreements: **For further study on** **whether and how to support** **PUCCH carrier switching** **in a PUCCH group, focus on the following three alternatives:**

* **Alt. 1: PUCCH carrier switching is based dynamic indication in DCI**
* **Alt. 2B: PUCCH carrier switching is based on certain (semi-static) rules**
* **Alt. 2C: PUCCH carrier switching is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells**
* Note: In above alternatives, it is assumed that HARQ-ACK corresponding to PDSCH received on a Pcell/PScell or an Scell in a PUCCH group, can be sent on a PUCCH onan Scellalso instead ofonly onPcell/PScell/PUCCH-SCellin the same PUCCH group, as opposed to Rel-16 where HARQ-ACK corresponding to PDSCH received on a Pcell/PScell or an Scell in a PUCCH group can only be sent on Pcell/PScell/PUCCH-SCell in the same PUCCH group.
* ***Note: Realistic deployment scenarios including TDD configurations should be considered for the study***

**RAN1#104b-e (April 2021)**

Agreements: For SPS HARQ-ACK deferral, for the determination of valid symbols in the target slot/sub-slot a collision with semi-static DL symbols, SSB and CORESET#0 is regarded as ‘invalid’ or ‘no symbols for UL transmission’.

Agreements: For SPS HARQ-ACK deferral, support a limit on the maximum deferral of SPS HARQ in terms of *k1def* or *k1*+ *k1def*

* + FFS: limitation given by a maximum value of *k1def* or a maximum of *k1eff* =*k1*+ *k1def*
  + FFS how the limitation is determined (e.g. by K1 set(s) or RRC configured limit)

Agreements: For SPS HARQ-ACK deferral, there is no lower limit defined for *k1def*

**Conclusion:**

No support for dynamic indication of skipped SPS PDSCH occasions in Rel-17 as part of this WI.

Agreement: Restrict the further discussions on the initial slot handling for SPS HARQ-ACK deferral to the identified alternatives Alt. 1, Alt. 1A and 2.

Agreement: For SPS HARQ-ACK deferral, the limit on the maximum deferral of SPS HARQ is defined in terms of *k1eff =k1*+ *k1def.*

Working assumption: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:

* In case the UE receives PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.

Agreement: For SPS HARQ-ACK deferral, the initial HARQ-ACK transmission occasion is considered to determine the out-of-order HARQ condition

Agreement: Support Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration in Rel-17.

* The properties of the Type-1 HARQ-ACK codebook for sub-slot PUCCH at least includes that a PDSCH TDRA is associated with a UL /PUCCH sub-slot if the end of the PDSCH overlaps with the associated sub-slot determined by a k1 in the set of sub-slot timing values K1.
* FFS: whether the PDSCH TDRA grouping is performed per DL slot or sub-slot
  + Decide between PDSCH TDRA grouping per DL slot and sub-slot during RAN1#105-e

**RAN1#105-e (May 2021)**

Working Assumption: For at least HARQ-ACK re-transmission:

* Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16) in Rel-17
  + *Definition of enhanced Type 3 CB:* 
    - *The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration*
    - *The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)*
* Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17
  + *Details are FFS*
* Enhanced Type 3 HARQ-ACK CB and/or one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB are subject to separate UE capabilities

Agreement: Support PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH and semi-static configuration

* Details are FFS (including applicability of dynamic and/or semi-static means)
* Aim for minimum specification impact
* Dynamic indication and/or semi-static configuration are subject to separate UE capabilities
* The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells and supports PUCCH carrier switching across cells with different numerologies.
  + FFS whether additional rules are needed to support PUCCH carrier switching across cells with different numerologies
* FFS the maximum number of PUCCH cells
* FFS whether and how to support joint operation of dynamic and semi-static carrier switching for a UE
* FFS whether and how to support joint operation of PUCCH carrier switching and SPS HARQ-ACK deferral

Agreement: For PUCCH carrier switching, the PUCCH resource configuration is per UL BWP (i.e. per candidate cell and UL BWP of that specific candidate cell).

Agreement: For PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH (i.e. Alt. 1), the PDSCH to HARQ-ACK offset k1 is interpreted based on the numerology of the dynamically indicated target PUCCH cell.

**RAN#92-e (June 2021) – *see section 3.2 of*** [***RP-211569***](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_92e/Docs/RP-211569.zip)

During the GTW session the following recommendations with further revisions were endorsed.

* **……**
* **Revised Recommendation2**: Provide the following RAN guidance on *HARQ-ACK enhancement [RAN1]*
  + No further discussions on SPS HARQ-ACK skipping and size reduction~~bundling/compression~~.

**RAN1#106-e (Aug. 2021)**

**Agreement**

The SPS HARQ-ACK deferral is enabled per SPS configuration

* Note: part of sps-config, only HARQ-ACK of SPS PDSCH configurations enabled for deferral is in principle subject to deferral

Agreement

Definition of when to defer from the initial slot:

Alt1: Deferral only, if the SPS HARQ-ACK in the initial slot/sub-slot cannot be transmitted as the resulting PUCCH resource for transmission using the PUCCH by SPS-PUCCH-AN-List-r16 or n1PUCCH-AN is not valid

**Agreement**

Update the following RAN1#105-e agreement as:

* RAN1#105-e Agreement: For PUCCH carrier switching, the PUCCH ~~resource~~ configuration (i.e. *pucch-Config / PUCCH-ConfigurationList*) is per UL BWP (i.e. per candidate cell and UL BWP of that specific candidate cell).
  + FFS: CSI and SR

# Appendix B: Summary of companies’ proposals

In here, the proposals and some example figures are collected for easier referencing.

### R1-2106490 UE feedback enhancements for HARQ-ACK Huawei, HiSilicon

***Observation 1: For sub-slot based Type 1 codebook, per slot based grouping has limited changes for codebook generation procedure on top of the legacy specification.***

***Observation 2: For sub-slot based Type 1 codebook, per slot based grouping can reduce non-negligible bit number of HARQ-ACK feedback compared to per sub-slot based grouping.***

**Proposal 1: *The maximum deferral k1*+ *k1def of the SPS HARQ-ACK should be the maximum k1 value in dl-DataToUL-ACK.***

**Proposal 2：*Down select between Alt.1 and Alt.1A as the SPS deferral condition:***

* ***Alt. 1: “If SPS HARQ-ACK is multiplexed with any other UCI / dynamic PUCCH resource then it cannot be deferred!”***
* ***Alt. 1A “Defer SPS HARQ even if multiplexing & transmission based on PRI in initial slot would be possible”.***

**Proposal 3: *For codebook construction for deferred SPS HARQ-ACK in the target slot,***

* ***For Type 1 CB, deferred SPS HARQ-ACK with k1+ k1def included in the K1 set can be mapped in the Type 1 CB following the Rel-15/Rel-16 rule, while those with k1+ k1def not included in the K1 set can be appended.***
* ***For SPS only CB and type 2 CB, Rel-16 rules can be reused.***

**Proposal 4: *For a candidate target slot/sub-slot, if the resulting PUCCH resource is unavailable, both the SPS HARQ-ACK(s) which have been deferred to this slot/sub-slot and the SPS HARQ-ACK originally pointed to this slot/sub-slot should be deferred in together to the next candidate slot/sub-slot.***

**Proposal 5：*Support TDRA grouping performed per slot for sub-slot based*** ***Type 1 CB,***

* ***Step 1: Determine DL slots consisting of DL sub-slots associated to the determined UL sub-slot***
* ***Step 2: In each determined DL slot, prune the PDSCH SLIVs whose ending symbols overlap with DL sub-slots that not associated to the determined UL sub-slot based on K1 set.***
* ***Step 3: Perform per slot SLIV splitting among the remaining SLIVs for each slot to generate the TDRA groups, each group of which is associated with the HARQ-ACK bit field.***

**Proposal 6: *Confirm the WA in the Coverage Enhancements WI where the repetition factor is dynamically indicated by the PRI field, and the PUCCH repetition factor is configured per PUCCH resource.***

**Proposal 7: *Support slot-based PUCCH repetition for PUCCH Format 0 and Format 2.***

**Proposal 8: *For dynamic indicating the target PUCCH carrier, consider to introduce a new field in DCI and a configured carrier set consisting of candidate carrier indices.***

**Proposal 9: *For*** ***interpreting the PDSCH to HARQ-ACK offset k1 under dynamic carrier indication, the K1 set configured for the indicated carrier should be used.***

**Proposal 10: *For the codebook construction in case of PUCCH carrier switching, HARQ-ACKs with same priority index pointed to the same slot/sub-slot on the same carrier will be constructed as one codebook.***

**Proposal 11: *For PUCCH carrier switching across different numerologies, the OoO rule between the carriers with PDSCH transmission and the carrier with PUCCH transmission should be applied based on the largest SCS.***

**Proposal 12: *For configuration of the RRC configured PUCCH carrier timing pattern,***

* ***The reference numerology is the SCS of PCell and the granularity of the timing pattern is based on the SCS of PCell.***
* ***K1 interpretation is based on K1 set configured for PCell.***

**Proposal 13: *For PUCCH carrier switching across different numerologies based on RRC configured timing pattern, the target slot on the target carrier for PUCCH transmission is the first available slot overlapping with the reference slot of the PUCCH carrier timing pattern.***

**Proposal 14: *For PUCCH carrier switching, consider to determine the target carrier for each PUCCH repetition individually based on the availability carrier of the slot.***

**Proposal 15: *Support joint operation of PUCCH carrier switching and SPS HARQ-ACK deferral.***

* ***For each candidate target slot/sub-slot, the UE will check its validity on its associated target carrier based on the PUCCH carrier switching pattern, until an available PUCCH resource is identified to carry the deferred SPS HARQ-ACK.***

**Proposal 16: *For dynamic HARQ-ACK scheduled by fallback DCI with DCI format 1\_0,***

* ***If semi-static carrier switching is configured, it will be transmitted based on semi-static carrier switching.***
* ***Otherwise, it should be transmitted on PCell.***

**Proposal 17：*If supporting Type 3 CB(s) with smaller size (compared to Rel-16) in Rel-17, the codebook size is determined only by RRC configuration, i.e. no any additional dynamic signaling involved.***

### R1-2106586 HARQ-ACK enhancements for Rel-17 URLLC vivo

***Proposal 1: The SPS HARQ-ACK deferral is configured per SPS configuration.***

***Proposal 2: For the conditions for SPS HARQ-ACK deferral from/within the initial slot/sub-slot, support Alt.1, i.e., if SPS HARQ-ACK is multiplexed with any other UCI/dynamic PUCCH resource then it cannot be deferred.***

***Proposal 3: multi-CSI-PUCCH-ResourceList, as well as pucch-CSI-ResourceList, is supported as candidate PUCCH resource(s) when performing SPS HARQ-ACK multiplexing with CSI.***

***Proposal 4: The PUCCH resource(s) for the deferred SPS HARQ-ACK should re-use the PUCCH resource(s) for HARQ-ACK corresponding to DL dynamic scheduling configured in one or more PUCCH resource sets and the PUCCH resource(s) configured for SR and/or CSI, subject to UCI multiplexing between SPS HARQ-ACK and other UCI(s), as well as the PUCCH resource(s) configured for SPS HARQ-ACK transmissions in Rel-15/16.***

***Proposal 5: In a potential target slot/sub-slot, the deferral decision takes the UCI multiplexing into account, and the same logic applied to the initial slot/sub-slot should be applied to the target slot/sub-slot.***

***Proposal 6:*** ***It should be determined if there is any limitation for k1eff applied to deferred SPS HARQ-ACK, and regarding the limitation, following options could be considered:***

* ***Option 1: k1eff should not exceed the maximum K1 configured by high layer.***
* ***Option 2: k1eff should correspond to a candidate K1 in the K1 set configured by high layer.***

***Proposal 7:*** ***It should be discussed how to construct the HARQ-ACK codebook containing deferred SPS HARQ-ACK, and for Type-1 codebook the codebook construction is highly dependent on the determination of k1eff for deferred SPS HARQ-ACK.***

***Proposal 8:*** ***Support including priority indication in a DCI format triggering Type-3 codebook, which is used to indicate the priority for the PUCCH transmission conveying the triggered Type-3 codebook.***

***Proposal 9:*** ***For a given configured serving cell, HARQ-ACK corresponding to all configured HARQ processes should be multiplexed in a Type-3 codebook, irrespective of corresponding latest scheduled or configured priority for each HARQ process.***

***Proposal 10:*** ***For enhanced Type-3 codebook, support multiple codebook sizes.***

***Proposal 11:*** ***For enhanced Type-3 codebook, support dynamic indication or selection for the codebook size.***

***Proposal 12:*** ***Support the retransmission of cancelled HARQ-ACK by Type-2 codebook with clarification that PDSCH grouping is within each priority with maximum two PDSCH groups per priority.***

*Observation 1: Slot based PUCCH repetition for PUCCH formats 0 and 2 has been supported in M-TRP agenda.*

***Proposal 13:*** ***Support sub-slot based PUCCH repetition also for other UCI types, including SR and CSI.***

***Proposal 14:*** ***For PUCCH carrier switching Alt. 1, support including a new field in DL scheduling DCI to indicate the target PUCCH cell.***

***Proposal 15:*** ***For PUCCH carrier switching Alt. 1, SPS HARQ-ACK may be multiplexed with DG HARQ-ACK corresponding to non-fallback DCI format due to overlapping, then transmitted on the target PUCCH cell indicated for the DG HARQ-ACK.***

***Proposal 16: For PUCCH carrier switching Alt. 1, SPS HARQ-ACK, SR or CSI may be configured or indicated to be transmitted on same or different PUCCH cell(s).***

***Proposal 17:*** ***For PUCCH carrier switching Alt. 2C, the time domain pattern is configured commonly for a PUCCH cell group, and only an active PUCCH cell is expected at a given time.***

***Proposal 18:*** ***For PUCCH carrier switching Alt. 2C, support the followings:***

* ***A reference SCS/numerology for the time domain pattern is configured by RRC.***
* ***The reference SCS/numerology is smaller than or equal to a SCS/numerology for any configured UL BWP for any PUCCH cell in the PUCCH cell group.***
* ***The granularity for the time domain pattern is a UL slot determined by the reference SCS/numerology.***

***Proposal 19:*** ***For PUCCH carrier switching, support configuring the K1 set individually for each PUCCH cell, for which the SCS/numerology of the PUCCH cell is applied.***

***Proposal 20:*** ***Support PUCCH carrier switching Alt. 2C at least for SR, as well as HARQ-ACK.***

### R1-2106636 HARQ-ACK Feedback Enhancements for URLLC/IIoT Nokia, Nokia Shanghai Bell

The discussions **in Sec. 2 on dropping of SPS HARQ-ACK feedback in TDD operation** can be summarized in the following related observations and proposals:

**Proposal 2.1: For the conditions for deferring SPS HARQ-ACK in the initial slot, in the case no dynamic PUCCH is scheduled on the initial slot, support Alt. 1: Defer if the SPS HARQ-ACK in the initial slot/sub-slot cannot be transmitted as the resulting PUCCH resource for transmission using a PUCCH provided by *SPS-PUCCH-AN-List-r16* or *n1PUCCH-AN* is not valid.**

* **FFS: whether PUCCH resources in *multi-CSI-PUCCH-ResourceList* and *pucch-CSI-ResourceList* should also be considered as candidate resources for reporting the HARQ-ACK feedback in the initial slot or not.**

**Proposal 2.2: For SPS HARQ-ACK deferral, the target slot is determined as the earlier of a valid PUCCH of *sps-PUCCH-AN-List-r16* / *n1PUCCH-AN*, or a dynamically indicated PUCCH resource (from *PUCCH-ResourceSet*).**

**Proposal 2.3: For constructing the HARQ-ACK codebook in the target slot, the deferred SPS HARQ-ACK bits are simply amended to the initial HARQ-ACK bits in the target slot.**

**Proposal 2.4: SPS HARQ-ACK deferral is configured separately per SPS configuration.**

**Proposal 2.5: The maximum allowed deferral value *k1eff\_max* having value range up to 15 is configured per individual SPS configuration, i.e. as part of *SPS-Config*.**

The discussions **in Sec. 3 on PUCCH repetition enhancements** can be summarized in the following related observations and proposals:

***Observation 3.1: The working assumption on a configurable PUCCH repetition factor per PUCCH resource from the Coverage Enhancements WI seems to be directly applicable also for URLLC operation and no changes seem to be required. The interaction of the dynamic repetition indication and the Rel-15 RRC configured repetition numbers in ‘nrofSlots’ is better to be discussed as part of the Coverage Enhancements WI (in AI 8.8.2).***

**Proposal 3.1: For the Rel-15 RRC configured PUCCH repetition factor using ‘*nrofSlots*’ in *PUCCH-config*, the configured repetition factor is applicable for the same UCI types for sub-slot based PUCCH repetition as for slot-based PUCCH repetition, including HARQ-ACK, SR and CSI.**

**Proposal 3.2: The RRC configured PUCCH repetition factor using ‘*nrofSlots*’ in *PUCCH-config* for PUCCH formats 0 and 2 should be applicable for sub-slot and slot-based PUCCH configurations.**

**Proposal 3.3: RAN1 to discuss changes to the PUCCH repetition framework for URLLC/IIoT including:**

* **Change of dropping behavior for PUCCH repetition: Drop a PUCCH repetition overlapping with a high-priority DG PUSCH to prevent high-priority UL-SCH data dropping.**
* **Enable multiplexing of HARQ-ACK & SR (at least for PUCCH of priority index 1) to reduce SR latency.**

The discussions **in Sec. 4 on Type 1 HARQ ACK Codebook for sub-slot PUCCH and related enhancements** can be summarized in the following related observations and proposals:

**Proposal 4.1: For Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration, support TDRA pruning/grouping per DL slot after TDRA determination per UL sub-slot.**

The discussions **in Sec. 5 on retransmissions of dropped HARQ-ACK** can be summarized in the following related observations and proposals:

**Proposal 5.1: For Type 3 codebook enhancements for URLLC, RAN 1 to consider**

* **Limiting the enhanced Type 3 CB to RRC configured subsets of HARQ processes / IDs or serving cells**
* **Support dynamic indication of the RRC configured Type 3 CB subset from multiple enhanced Type 3 CB alternatives only by a triggering DCI that does not schedule PDSCH. For a triggering DCI also scheduling PDSCH, only a fixed single RRC configured enhanced Type 3 CB can be triggered.**
* **Including the support for Type 3 CB triggering using DCI format 1\_2.**
* **Triggering DCI including a PHY priority indication for the PUCCH carrying the Type-3 CB.**

**Proposal 5.2: Support one-shot HARQ-ACK codebook re-transmission on PUCCH with a dynamic indication of the timing of the HARQ-ACK CB (of a specific PUCCH occasion) to be re-transmitted. The re-transmission triggering DCI does not schedule PDSCH (allowing maintaining DCI size) and e.g. the HARQ ID field can be used to indicate the offset between the target PUCCH occasion and the PUCCH occasion of the HARQ-ACK CB to be re-transmitted.**



**Figure 5.1. Indication of the HARQ-ACK codebook to be retransmitted using the slot   
for the PUCCH re-transmission as timing reference.**

**Proposal 5.3: For PUCCH carrying a triggered enhanced Type 3 HARQ-ACK codebook (of smaller size), only HARQ-ACK information of HARQ processes included in the enhanced Type 3 HARQ-ACK codebook are transmitted. Any ‘new, initial’ HARQ-ACK information for transmission in the same PUCCH slot that is not mapped to the enhanced Type 3 CB is not transmitted.**

**Proposal 5.4: For one-shot triggering of HARQ-ACK re-transmission on PUCCH, in case the dynamic Type 2 HARQ-ACK codebook is configured, the HARQ-ACK codebook on the indicated PUCCH is constructed by amending the Type 2 HARQ-ACK codebook to be re-transmitted to the Type 2 HARQ-ACK codebook of the indicated PUCCH (carrying new, initial HARQ-ACK information).**

**Proposal 5.5: For one-shot triggering of HARQ-ACK re-transmission on PUCCH, in case the semi-static Type 1 HARQ-ACK CB is configured, the HARQ-ACK codebook contains the Type 1 HARQ-ACK codebook to be re-transmitted. The UE does not expect to be triggered for new, initial HARQ-ACK transmission in the same PUCCH slot/sub-slot.**

The discussions **in Sec. 6 on dynamic PUCCH carrier switching** can be summarized in the following related observations and proposals:

**Proposal 6.1: The PUCCH carrier switching is limited to a maximum of three additional PUCCH cells (i.e. 4 PUCCH cells in total) for Rel-17.**

**Proposal 6.2: PUCCH carrier switching based on dynamic indication is in principle supported for PUCCH scheduled by DCI format 1\_1 or 1\_2 but not for PUCCH scheduled by the fallback DCI format 1\_0.**

**Proposal 6.3: Support an RRC configured list of target PUCCH cells in terms of serving cell indexes within *CellGroupConfig*, which is used for indexing of the target PUCCH cell for PUCCH carrier switching based on dynamic indication and/or semi-static time-domain pattern configuration.**

* **FFS: If the PCell/PSCell cell is included in the list (e.g. as the first entry) or if only the additional PUCCH cells are configured.**

**Proposal 6.4: Support the following flexible configurations for the DCI format usage and DCI bit field size:**

* **The dynamic indication of the target PUCCH cell using DCI format 1\_1 is RRC configured through the explicit new DCI field size configuration {i.e. 1 or 2 bit} for DCI format 1\_1 in *PhysicalCellGroupConfig*.**
* **The dynamic indication of the target PUCCH cell using DCI format 1\_2 is RRC configured through the explicit new DCI field size configuration {i.e. 1 or 2 bit} for DCI format 1\_2 in *PhysicalCellGroupConfig*.**

**Proposal 6.5: When DCI indicates PUCCH transmission in an Scell slot that is longer than Pcell slot, the following applies for HARQ-ACK multiplexing from Pcell:**

* **HARQ-ACK from a Pcell PUCCH overlapping with the indicated PUCCH on Scell is multiplexed on the SCell**
* **HARQ-ACK transmission configured or scheduled for more than one Pcell PUCCH slot overlapping with the indicated PUCCH on Scell is considered as an error case.**

**Proposal 6.6: When DCI indicates PUCCH transmission in an Scell slot that is shorter than the Pcell slot, the following applies for HARQ-ACK multiplexing:**

* **HARQ-ACK from overlapping Pcell PUCCH is multiplexed on Scell PUCCH**
* **Pcell PUCCH with HARQ-ACK overlapping with Scell PUCCHs in multiple Scell slots is considered as an error case.**

**Proposal 6.7: For PUCCH carrier switching based on dynamic indication, if the UE is configured with Type 1 HARQ-ACK codebook:**

* **The UE is not expected to be configured for a first (or second) PUCCH configuration with non-aligned PUCCH slots or sub-slots boundaries (i.e. start/end) across all configured PUCCH target cells.**
* **The UE is not expected to be configured with different k1 sets for a first (or second) PUCCH configuration across all configured PUCCH target cells.**

***Note: This is to limit the specification and implementation impact on the Type 1 HARQ-ACK codebook construction /pseudo code due to different k1 sets, SCS and slot/sub-slot configurations.***

***Observation 6.1: For PUCCH carrier switching based on dynamic indication, if the UE is configured with Type 2 HARQ-ACK codebook and the PCell and target PUCCH cell have the same SCS and slot- or same sub-slot based PUCCH configuration, the Rel-15/16 Type 2 HARQ-ACK codebook construction can be directly reused as the PUCCH slots or sub-slots are aligned across PCell and the target PUCCH cell.***

**Proposal 6.8: For PUCCH carrier switching based on dynamic indication, if the UE is configured with Type 2 HARQ-ACK codebook and PUCCH slots- or sub-slots of a PUCCH configuration are not aligned at the PCell and the target PUCCH cell, the following Type 2 HARQ-ACK construction is applied:**

* **The HARQ-ACK on PUCCH on PCell is only multiplexed on the target PUCCH cell, if the PUCCHs of PCell and target Scell are overlapping. In this case, the Type 2 CB DAI mechanism applies to the overall Type 2 CB to be transmitted on the target PUCCH cell.**
* **If the PUCCHs carrying HARQ-ACK on PCell and the target PUCCH cell are not overlapping, the HARQ-ACK is to be independently transmitted on PCell and the target PUCCH cell. The Type 2 CB DAI mechanism is independently applied for the Type 2 HARQ-ACK codebooks transmitted on PCell and the target PUCCH cell.**

**Proposal 6.9: PUCCH carrier switching, based on dynamic indication on DCI, should be limited to HARQ-ACK and SR only (i.e. PUCCH carrier switching for CSI is not to be supported).**

**Proposal 6.10: Support independent PUCCH TPC loops for the individual PUCCH cells within a cell group both for PUCCH carrier switching based on dynamic indication and semi-static configuration.**

**Proposal 6.11: For PUCCH TPC operation of PUCCH carrier switching based on dynamic indication and semi-static configuration, support the configuration of individual TPC command starting points within DCI format 2\_2 for each PUCCH candidate SCell in *PUCCH-TPC-CommandConfig*.**

**Proposal 6.12: For PUCCH carrier switching based on dynamic indication, the PUCCH TPC command in the DCI scheduling the PUCCH at the target PUCCH cell is applicable only for the (dynamically indicated) target PUCCH cell.**

**Proposal 6.13: For PUCCH carrier switching based on semi-static configuration, the PCell/PSCell SCS defines the reference numerology of the time domain pattern of applicable PUCCH cells. The PCell/PSCell is the reference cell for determining the PUCCH (sub-) slot to determine the PUCCH cell based on the configured time domain pattern of applicable PUCCH cells.**

**Proposal 6.14: The granularity of the time-domain pattern for PUCCH carrier switching is defined as an UL slot of the reference cell (i.e. PCell/PSCell).**

**Proposal 6.15: The gNB will need to guarantee by configuration of the time-domain pattern for PUCCH carrier switching, that the PUCCH carrier switching points are to be aligned with PUCCH slot/sub-slot boundaries of a PUCCH cell.**

**Proposal 6.16: The time-domain pattern is RRC configured per PUCCH cell group (i.e. within *CellGroupConfig*) for the UE and a pattern length of up to 10ms should be supported, i.e. a pattern length of up to *maxNrofSlots*.**

**Proposal 6.17:** **With semi-static PUCCH cell switching to longer Scell slot, gNB implementation takes care of that timelines are met for PUCCH transmission switching to Scell.**

**Proposal 6.18: With semi-static PUCCH cell switching to longer Scell slot, the UE does not expect to be indicated for HARQ-ACK codebooks in more than one of the PCell slots overlapping with a single Scell slot configured for PUCCH transmission.**

**Proposal 6.19: For PUCCH carrier switching based on semi-static configuration to an Scell with shorter slots, the PUCCH slot on the Scell is determined by combining PDSCH timing, indicated PCell k1 value, and indicated Scell k1\_relative value, where the k1\_relative value of the Scell indicates the Scell slot within the PCell slot.**

**Proposal 6.20: For PUCCH carrier switching based on semi-static configuration, the Type 1 HARQ-ACK codebook uses the k1 set(s) configured for the PCell / reference cell for the HARQ-ACK codebook construction.**

**Proposal 6.21: For PUCCH carrier switching based on semi-static configuration, the Rel-15/16 Type 2 HARQ-ACK codebook construction (based on the k1 interpretation on the PCell) can be directly reused.**

**Proposal 6.22: PUCCH carrier switching, based on semi-static configuration, should be limited to HARQ-ACK and SR only (i.e. PUCCH carrier switching for CSI is not to be supported).**

**Proposal 6.23: For PUCCH carrier switching based on semi-static configuration, the PUCCH TPC command in the DCI scheduling the PUCCH is applied for the determined PUCCH cell using the defined semi-static (i.e. time-domain pattern) PUCCH cell selection procedure.**

***Observation 6.2: Discussions on joint operation of dynamic and semi-static operation should be postponed after having more clarity on the operation of stand-alone PUCCH carrier switching based on (i) dynamic indication and (ii) semi-static configuration. A guiding principle for the potential joint operation of the two schemes could be that the dynamically indicated PUCCH Cell ‘overrides’ the determined PUCCH cell based on the time-domain PUCCH cell pattern.***

### R1-2106678 HARQ-ACK Enhancements for IIoT/URLLC Ericsson

In the previous sections we made the following observations:

* Observation 1 For the joint operation of PUCCH carrier switching and SPS HARQ-ACK deferral, lower latency for SPS HARQ-ACK transmission can be achieved if PUCCH carrier switching of SPS HARQ-ACK is performed first.
* Observation 2 The semi-static configuration of PUCCH cell timing pattern containing ‘slot\_offset’ parameter can be used to obtain the SPS HARQ-ACK deferral behavior.
* Observation 3 The initial slot handling for SPS HARQ-ACK deferral essentially leads to a simple updated procedure on determining the new actual K1. This can be done separately prior to the existing multiplexing and PUCCH resource determination procedures.

Based on the discussion in the previous sections we propose the following:

**Proposal 1 Dynamic indication of a PUCCH carrier is done by a field in the DCI.**

**Proposal 2 Dynamic PUCCH carrier switching is applicable to any scheduled PUCCH carrying HARQ-ACK in response to dynamic PDSCH/ SPS PDSCH/ SPS release or triggered PUCCH carrying a Type-3 HARQ-ACK codebook.**

**Proposal 3 For semi-static PUCCH carrier switching, the PUCCH cell timing pattern contains PUCCH cell indices configured for each slot in the PCell or PUCCH-SCell of a PUCCH group.**

**Proposal 4 For semi-static PUCCH carrier switching, the PUCCH cell timing pattern consists of PUCCH cell index and slot offset values, (‘cell\_index’, ‘slot\_offset’) configured for each slot in the PCell or PUCCH-SCell of a PUCCH group.**

**Proposal 5 Semi-static PUCCH carrier switching is applicable to any PUCCH including PUCCH carrying SR, periodic/semi-persistent CSI, PUCCH carrying HARQ-ACK for SPS PDSCH/SPS release/dynamic PDSCH.**

**Proposal 6 PUCCH carrier switching mode ‘dynamic’, ‘semi-static’, or ‘dynamic and semi-static’ can be configured to a UE.**

**Proposal 7 A subset of applicable PUCCH cells for PUCCH carrier switching within a PUCCH group can be configured to a UE per PUCCH group.**

**Proposal 8 For dynamic indication of PUCCH carrier switching, the PUCCH carrier indicator field size is determined based on the largest set of applicable PUCCH cells among PUCCH groups subject to dynamic PUCCH carrier switching.**

**Proposal 9 If the UE is both indicated a PUCCH carrier indication by the DCI field and configured with PUCCH cell timing pattern, the UE follows the dynamic PUCCH carrier indication and ignores the semi-static PUCCH cell timing pattern.**

**Proposal 10 For joint operation of PUCCH carrier switching and UCI multiplexing, the UE first performs PUCCH carrier switching for relevant UCIs to determine the target PUCCH cell, and then the existing UCI multiplexing procedures are followed, if needed.**

**Proposal 11 The UE does not expect to be indicated with HARQ-ACK transmission in PUCCHs overlapping in different PUCCH carriers.**

**Proposal 12 If PUCCH resource with HARQ-ACK transmission with dynamic PUCCH carrier indication overlaps with semi-static configured PUCCH resources, the UE multiplexes UCIs and transmits on PUCCH on the carrier indicated by the dynamic indication.**

**• An exception can be considered when SPS HARQ-ACK is multiplexed with CSI, the PUCCH carrier to use follows the carrier intended for the CSI.**

**Proposal 13 For the joint operation of PUCCH carrier switching and SPS HARQ-ACK deferral, PUCCH carrier switching of SPS HARQ-ACK is performed first, followed by SPS HARQ-ACK deferral on the target PUCCH cell, if needed.**

**Proposal 14 Support configuration of SPS HARQ-ACK deferral per SPS configuration (Option 2).**

**Proposal 15 Support Alt. 1A for the initial slot handling for SPS HARQ-ACK deferral.**

**Proposal 16 After the discussion on initial slot handling for SPS HARQ-ACK deferral is concluded, further discuss whether PUCCH resource determination enhancement for SPS HARQ-ACK in Alt. 2 is needed.**

**Proposal 17 Study potential update of Type-1 HARQ-ACK codebook procedure to support SPS HARQ-ACK deferral when k1eff is not included in the original set of configured K1 values. The update should not lead to an excessive increase of the HARQ-ACK codebook size.**

**Proposal 18 Support enhanced Type-3 HARQ-ACK codebook where only A/N of “activated CCs” are included in the codebook instead of all “configured CCs”.**

**Proposal 19 Introduce RRC configuration of a subset of HARQ processes of which the HARQ-ACK bits are included in the enhanced Type-3 HARQ-ACK codebook.**

**Proposal 20 For both Type-3 and enhanced Type-3 HARQ-ACK, support**

**- PHY priority indication can be included in the triggering DCI of the Type 3 and enhanced Type-3 HARQ-ACK codebook**

**- Both DCI formats 1\_1 and 1\_2 can be used for triggering the Type-3 and enhanced Type-3 HARQ-ACK codebook**

**- The priority indication is used only for selecting proper parameters for PUCCH transmission (i.e., proper PUCCH-config) and for the purpose of intra-UE prioritization**

**Proposal 21 When a HARQ-ACK codebook is dropped, the UE behavior with respect to the dropped HARQ-ACK is “as if the dropped HARQ-ACK codebook corresponds to DCI scheduling PDSCH with non-numerical K1 as in Rel-16”.**

**Proposal 22 Support a retransmission of the last dropped HARQ-ACK codebook by a DL assignment containing the timing and resource for the HARQ-ACK feedback.**

**Proposal 23 Support having a repetition factor for PUCCH repetition as part of the configuration of PUCCH resources and performing dynamic PUCCH repetition indication through the existing PRI field in the DCI (Confirming the working assumption in the CE WI).**

**Proposal 24 Dynamic PUCCH repetition can be applied to any UCI type (A/N, SR, CSI) and not limited only to HARQ-ACK.**

**Proposal 25 If a UE is configured with nrofSlots and is also provided with the dynamic repetition indication, the UE should follow the dynamic repetition indication and ignore the parameter nrofSlots.**

**Proposal 26 Support PUCCH repetition of PUCCH formats 0 and 2 also for slot-based PUCCH repetition for single TRP.**

**Proposal 27 Support Type-1 HARQ codebook for sub-slot HARQ-ACK by updating the pseudo code for determining a set of occasions for candidate PDSCH reception where the ratio 2^(μ\_DL-μ\_UL ) is changed to ⌊2^(μ\_DL-μ\_UL )/N⌋, where N is the number of sub-slots in an UL slot.**

### R1-2106697 Discussion on HARQ-ACK feedback enhancements for Rel-17 URLLC Spreadtrum Communications

***Proposal 1. For SPS HARQ-ACK deferral, a maximum deferring value can be configured by RRC signalling. If the RRC signalling does not exist, the maximum value of K1 set can be used as ae maximum deferring value.***

***Proposal 2. To handle Initial slot issue for SPS HARQ-ACK deferral, Alt. 2 is supported.***

***Proposal 3. For all the other configured PUCCH resources, a default rule can be used to choose one resource, e.g., the one with small resource index or the one with earliest starting symbol.***

***Proposal 4. The SPS HARQ-ACK deferral is configured per SPS configuration***

***Proposal 5. Support slot-based PUCCH repetition for PUCCH formats 0 and 2.***

***Proposal 6. Regarding how to how to indicate an enhanced Type 3 CB to the UE, using dynamic indication in the DCI is supported. The triggering DCI can also schedule PDSCH at the same time.***

***Proposal 7. NACK skipping should be supported, and it can be applied by both skipped and non-skipped SPS PDSCH.***

***Proposal 8. NACK skipping scheme can be configured by higher layer signalling for all configured SPSs.***

***Proposal 9. ACK skipping scheme can be considered for SPS HARQ payload size reduction of non-skipped SPS PDSCH.***

***Proposal 10. For Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration, support PDSCH TDRA grouping per sub-slot.***

### R1-2106734 Discussion on HARQ-ACK enhancements for eURLLC ZTE

***Observation 1:*** *Compared with Alt. 2, in order to support Alt. 1 (Type 3 CB), more issues need to be solved, which significantly increases the standardization work load.*

***Observation 2:*** *If multiple UL sub-slots correspond to a DL slot, it will potentially cause additional overhead for the type-1 HARQ-ACK codebook because the DL slot is used multiple times for construction of the type-1 HARQ-ACK codebook.*

***Observation 3:*** *Dividing SLIV group based on per slot can still work when UL sub-slot crossing 2 DL slots boundary.*

***Proposal 1:*** *The SPS HARQ-ACK deferral configured per SPS configuration should be supported.*

***Proposal 2:*** *Regarding the determination of valid symbols on SPS HARQ-ACK PUCCH deferring conditions:*

* *If an SPS HARQ-ACK PUCCH is determined to collide with the semi-statically configured* ***flexible*** *symbol in the slot, the SPS HARQ-ACK PUCCH should be transmitted.*

***Proposal 3:*** *Regarding SPS HARQ-ACK PUCCH deferring conditions:*

* *UE should determine whether the SPS HARQ-ACK PUCCH needs to be deferred before UCI multiplexing decision.*
* *UE determines the target slot from/within the initial slot/sub-slot.*

***Proposal 4:*** *Regarding the maximum value of k1def, it should be satisfied that the latest target UL slot/sub-slot corresponding to k1+k1def is the first UL slot/sub-slot after the initial slot/sub-slot.*

***Proposal 5:*** *For deferring HARQ-ACK until a next (e.g., first) available PUCCH, the PUCCH could be chosen from PUCCH resource sets for either SPS configuration or DG PDSCH starting from/within the initial slot.*

***Proposal 6:*** *For deferring HARQ-ACK until a next (e.g., first) available PUCCH, flexible symbols that from the start symbol of the original deferred PUCCH could be used for the available PUCCH for the deferred HARQ-ACK codebook.*

***Proposal 7:*** *For the next (e.g., first) available PUCCH for deferring HARQ-ACK, it needs to meet the following conditions in a slot:*

* *The size of the deferred HARQ-ACK codebook is within the UCI size range configured for the selected PUCCH.*
* *The number of the selected PUCCH symbols is not less than the number of original PUCCH symbols.*
* *The selected PUCCH has the earliest end symbol.*

***Proposal 8:*** *If the above conditions are not satisfied, the HARQ-ACK should be further deferred.*

***Proposal 9:*** *If the next available PUCCH for the deferred HARQ-ACK codebook for SPS PDSCH is determined in slot n and another PUCCH for the HARQ-ACK codebook for DG PDSCHs is also indicated in slot n, then the two HARQ-ACK codebooks should be multiplexed together in a same PUCCH determined by PRI in the last DCI.*

* *If the slot with SPS PDSCH is contained in the semi-static HARQ-ACK codebook window corresponding to the semi-static HARQ-ACK codebook for the DG PDSCHs, then UE constructs a new HARQ-ACK codebook containing the deferred HARQ-ACK and HARQ-ACKs of the DG PDSCHs according to the semi-static HARQ-ACK codebook mechanism, but the actual HARQ-ACK is always generated for the slot with SPS PDSCH.*
* *Otherwise, regardless of whether the UE is configured with a dynamic codebook or a semi-static codebook, the UE always concatenates the delayed HARQ-ACK codebook after the HARQ-ACK codebook for DG PUSCHs to generate a new HARQ-ACK codebook.*

***Proposal 10:*** *Regarding PUCCH repetition, especially sub-slot based PUCCH repetition:*

* *Regarding dynamic repetition indication, the method to be specified in Cov. Enh WI for slot-based PUCCH repetition can be directly applied to sub-slot PUCCH or changes are needed.*
* *‘nrofSlots’ is also applicable for sub-slot based PUCCH repetition.*
* *Both the dynamic indication and the number of sub-slots of PUCCH repetition configured by RRC should be supported, and the dynamic indication can override the RRC signaling.*
* *It is not necessary to consider slot-based PUCCH repetition for PUCCH formats 0 and 2.*

***Proposal 11:*** *RAN1 should consider the construction of the enhanced type 3 codebook based on the priority indication if the type 3 like codebook is supported for retransmission of the cancelled HARQ-ACK.*

***Proposal 12:*** *For the retransmission of the dropped HARQ-ACK codebook, Alt. 2 should be supported, i.e., DCI scheduling PUCCH to carry dropped HARQ-ACK codebook.*

* *In order to support one or more HARQ-ACK codebooks to be scheduled, the following detailed methods can be considered:*
  + *Solution 1: Support a DCI triggering (by a DL assignment) of one HARQ-ACK codebook re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB in Rel-17.*
* *The identification bit is included in the DCI based on the configuration of the RRC signaling and indicates that the DCI is used to schedule the cancelled codebook.*
  + *Solution 2: Support a new DCI format for scheduling one or more cancelled HARQ-ACK codebooks.*
* *The fields of size of one or more HARQ-ACK codebooks are included in the DCI.*
* *The order of the multiple size fields of one or more HARQ-ACK codebooks in the DCI is determined based on the order of the PUCCHs starting symbols corresponding to the cancelled HARQ-ACK codebooks.*
* *The CRC of the DCI is scrambled by a predefined RNTI.*
* *PUCCH resource indication (PRI), indicates a PUCCH resource from the carrier used to transmit PUCCH.*
* *PDCCH-to-HARQ\_feedback timing indicator, indicates the slot interval between the PDCCH where the DCI is located and the PUCCH used to transmit the scheduled HARQ-ACK codebook.*

***Proposal 13:*** *The standardization work for retransmission of the low-priority HARQ-ACK codebook should be considered first.*

* *The similar principle could be applied for high priority HARQ-ACK retransmission if it does not require a lot of extra standardization work compared to low priority HARQ-ACK retransmission.*

***Proposal 14:*** *The cancelled HARQ-ACK codebook should be triggered for transmission as early as possible after the conflict is determined, for example, the earliest trigger is started after the PDCCH corresponding to the high-priority PUCCH.*

***Proposal 15:*** *The unnecessary repetitive construction of the type-1 HARQ-ACK codebook due to the fact that one DL slot corresponds to multiple uplink sub-slots should be prohibited.*

***Proposal 16:*** *For the type-1 HARQ-ACK codebook, if one UL sub-slot overlaps with one or more DL slots, the existing mechanism is reused, for example, loop multiple DL slots within one UL slot.*

***Proposal 17****: Determine the type1 HARQ-ACK codebook based on sub-slot with grouping per slot level with the following procedure:*

1. *Determine the DL slot corresponding to the type1 HARQ-ACK codebook;*
2. *Within the determined DL slot, if the end symbol of a PDSCH TDRA does not overlap with the determined UL sub-slot (n-k1), then delete the PDSCH TDRA from the PDSCH TDRA of the determined DL slot;*
3. *The remaining PDSCH TDRA in the determined DL slot is divided into SLIV groups per slot level;*
4. *Generate HARQ-ACK information for each SLIV group.*

***Proposal 18:*** *For dynamic PUCCH carrier switching, dynamic indication in DCI should be supported.*

* *PRI is used to instruct PUCCH carrier switching from a new configured PUCCH resource set, which can include PUCCH resources of different UL CCs.*

***Proposal 19:*** *For the semi-static PUCCH carrier switching configuration operation:*

* *Support to configure multiple carriers for PUCCH carrier switching.*
* *Support the configuration of a reference carrier.*
* *Support periodic configuration of PUCCH carrier based on the slot of the reference carrier.*
* *k1 is interpreted based on the reference carrier.*
* *PRI is interpreted based on the target PUCCH carrier.*

### R1-2106801 Considerations on HARQ-ACK enhancements for URLLC Sony

**Observation 1: The gNB is aware if the UE missed a dynamically scheduled PUCCH that could have multiplexed SPS HARQ-ACKs due to their corresponding PUCCH being dropped and therefore the gNB knows that the UE has deferred these SPS HARQ-ACKs.**

**Observations 2: Considering multiple PUCCH resources in a slot regardless of whether they collide with the SPS PUCCH, for multiplexing of SPS HARQ-ACK would lead to high specification impacts to define rules to select one out of multiple PUCCH resources.**

**Observation 3: The Rel-16 HARQ-ACK CB for SPS is able to transmit HARQ-ACKs for multiple SPS’s that have the same HPN.**

**Observation 4: When a same-HPN collision occurs for two or more SPSs due to SPS HARQ-ACK deferral, the UE may have to drop the soft bits for one or more PDSCHs of these SPS from its HARQ buffer.**

**Observation 5: In a same-HPN collision involving an earlier SPS with deferred HARQ-ACK and a later SPS without a deferred HARQ-ACK, always dropping either the earlier or later SPS would have an impact on the HARQ retransmission gains.**

**Observation 6: Misdetection of DL Grant does not cause misalignment between gNB and UE on the number of retransmitted HARQ-ACK for a dynamic HARQ-ACK CB (Dyn-ReTx CB) that retransmits the HARQ-ACKs from a dropped Type 1 HARQ-ACK CB.**

**Observation 7: Misalignment between gNB and UE on the number of retransmitted HARQ-ACK of a dropped Type 2 HARQ-ACK CB using Dyn-ReTx CB may be caused by the UE miss detecting the last DL Grant, thereby missing the last DAI increment, associated with that Type 2 HARQ-ACK CB.**

**Observation 8: e-Type 3 HARQ-ACK CB would never provide effective overhead reduction because the CB size is semi-statically configured whilst which HARQ-ACKs get dropped happens dynamically.**

**Observation 9: The enhancements in e-Type 3 HARQ-ACK CB basically attempt to semi-statically “*predict*” which HARQ-ACK would be dropped and hence it can never achieve CB size as optimal as that of a dynamic HARQ-ACK CB, i.e. Dyn-ReTx CB, that retransmits only dropped HARQ-ACKs.**

**Observation 10: Dynamically indicate in the triggering DCI one of multiple configured e-Type 3 CBs of different HARQ-ACK subsets to better target which HARQ-ACKs that may be dropped dynamically have the following issues:**

* **Many e-Type 3 CBs are needed to adapt to the dynamically changing number of dropped HARQ-ACKs but this would lead to high DCI overhead or reduced functionality of the DL Grant triggering the e-Type 3 CB**
* **Using less bits in the DCI or RNTI as the indicator would limit the number of e-Type 3 CB that can be configured, hence making it less effective in overhead reduction**

**Observation 11: Configuring multiple e-Type 3 CBs and using a dynamic indicator in the triggering DCI to indicate which e-Type 3 CB to use is still not as effective in overhead reduction compared to using a dynamic HARQ-ACK CB, Dyn-ReTx CB, that retransmits only dropped HARQ-ACKs.**

**Observation 12: If the number of dropped HARQ-ACK is small, it is significantly more efficient to retransmit them using Dyn-ReTx CB than to use an e-Type 3 CB.**

**Observation 13: If the number of dropped HARQ-ACK is large, it is more robust to retransmit them using an e-Type 3 CB compared to Dyn-ReTx CB.**

**Observation 14: Sub-slot PUCCH repetitions would lead to intra-UE PUCCH collision where PUCCH repetitions in a sub-slot collide with another PUCCH in another sub-slot.**

**Observation 15: The 2 levels of L1 priority introduced in Rel-16 for UL intra-UE prioritization is not sufficient to handle inter sub-slot PUCCH repetitive collisions.**

**Observation 16: The 1st PUCCH repetition has the highest importance compared to subsequent repetitions of the same PUCCH.**

We therefore propose the following:

**Proposal 1: Use the condition in Alt-1 for deferment of SPS HARQ-ACK, i.e. deferral only, if the SPS HARQ-ACK in the initial slot/sub-slot cannot be transmitted as the resulting PUCCH resource for transmission using the PUCCH by *SPS-PUCCH-AN-List-r16* or *n1PUCCH-AN* is not valid**

**Proposal 2: Reuse the Rel-16 SPS HARQ-ACK only CB to include deferred SPS HARQ-ACK.**

**Proposal 3: Reuse the Rel-16 mechanism to append deferred SPS HARQ-ACK to a dynamic HARQ-ACK CB.**

**Proposal 4: Do NOT agree the following Working Assumption:**

***Working assumption: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:***

* ***In case the UE receives PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.***

**Proposal 5: In a same-HPN collision involving two or more SPS due to SPS HARQ-ACK deferment, if the UE needs to drop PDSCH soft bits from one or more of these SPS’s, the UE will drop the SPS’s that has been successfully decoded.**

**Proposal 6: The dynamic HARQ-ACK CB (Dyn-ReTx CB) for HARQ-ACK retransmission is triggered using the “*One-shot HARQ-ACK request*” in DCI 1\_1. FFS whether to introduce “*One-shot HARQ-ACK request*” for DCI 1\_2.**

**Proposal 7: The DCI that triggers for the dynamic HARQ-ACK CB (Dyn-ReTx CB) to retransmit HARQ-ACK from a dropped Type 2 HARQ-ACK CB, will also indicate the DAI value of the last DL Grant associated with that dropped Type 2 HARQ-ACK CB.**

**Proposal 8: The UE is configured with the Dyn-ReTx CB and an e-Type 3 CB and when triggered by a DCI to retransmit HARQ-ACKs, the UE selects one of these CBs depending on the number of dropped HARQ-ACK:**

* **If the number of dropped HARQ-ACK ≤ *THARQ*, the UE selects Dyn-ReTx CB**
* **If the number of dropped HARQ-ACK > *THARQ*, the UE selects e-Type 3 CB**

**Proposal 9: If sub-slot PUCCH repetition is introduced, consider reducing the priority of a repetition according to the number of repetitions that have already been transmitted.**

### R1-2106879 On HARQ-ACK reporting enhancements Samsung

**Proposal 1: Support Alt. 2 “intra-slot deferral before inter-slot deferral” for SPS HARQ-ACK deferral.**

**Proposal 2: Support same principle for both initial slot and target slot for SPS HARQ-ACK deferral.**

**Proposal 3： Confirm the working assumption in RAN1#104e-bis with following update:**

**Updated Working assumption: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:**

* **In case the UE ~~receives~~ is configured to receive a PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.**

**Proposal 4: Support Type-3 CB triggering using DCI format 1\_2.**

* **The triggering using DCI format 1\_2 is RRC configured.**

**Proposal 5: RRC configures N report states (HPNs, cell IDs) for a Type-3 HARQ-ACK CB and a One-Shot HARQ-ACK request field of ceil(log2(N) bits in DCI format 1\_1/1\_2 indicates the report state.**

**Proposal 6: RRC configures N>1 report states (HPNs, cell IDs) for a Type-3 HARQ-ACK CB and a One-Shot HARQ-ACK request field of 1 bit in DCI format 1\_1/1\_2 and, when the One-Shot HARQ-ACK request field value is 1, there is no scheduled PDSCH and a redundant field indicates the report state.**

**Proposal 7: RRC configures a One-Shot HARQ-ACK request field of N bits in DCI format 1\_1/1\_2 that triggers from a UE a HARQ-ACK report that the UE was scheduled to provide in one of the previous 2N-1 UL slots or one of the previous N UL slots in case of a bitmap.**

**Proposal 8: RRC configures a One-Shot HARQ-ACK request field of 1 bit in DCI format 1\_1/1\_2 and, when the One-Shot HARQ-ACK request field value is 1 and the Rel-16 conditions for no scheduled PDSCH are satisfied, redundant field(s) provide a bitmap that indicates previous UL slots and a UE is triggered to provide HARQ-ACK reports that the UE was scheduled to provide in the indicated previous UL slots.**

**Proposal 9: Support skipping of a PUCCH transmission with NACK-only HARQ-ACK information.**

**Proposal 10: Support all UCI types for sub-slot based PUCCH repetition.**

**Proposal 11: Type-1 codebook for sub-slot based PUCCH supports PDSCH TDRA grouping per DL slot as in Rel-15/16.**

**Proposal 12: The maximum number of PUCCH cells is 2.**

**Proposal 13: The unit of the time pattern is the slot of the cell with the smaller SCS.**

**Proposal 14: The time unit of the PDSCH-to-HARQ\_feedback timing field for RRC-based PUCCH cell switching is based on the smaller SCS of the PUCCH cells. When a UE is indicated to transmit PUCCH on the cell with larger SCS, the UE transmits the PUCCH in the first slot that overlaps with the indicated slot on the cell with smaller SCS.**

**Proposal 15: When a slot of a first cell overlaps with one or more slots of a second cell, a UE does not expect to transmit PUCCH in both the slot of the first cell and in any of the one or more slots of the second cell.**

**Proposal 16: When a UE is indicated a slot by a DCI format that overlaps with a slot indicated by a PUCCH cell timing pattern, the UE determines the cell for a PUCCH transmission from the indication by the DCI format.**

**Proposal 17: Conclude whether or not a UE can expect to transmit PUCCH (with HARQ-ACK associated with DCI formats) on a SCell/P(S)Cell when the UE can transmit PUCCH with HARQ-ACK for SPS PDSCHs or SR/CSI on P(S)Cell/SCell.**

**Proposal 18: A field of 1 bit in DCI formats 1\_1/1\_2 indicates the cell of an associated PUCCH transmission. If PUCCH cell switching is to be supported using DCI format 1\_0, 1 bit from the HPN or RV field indicates the cell of an associated PUCCH transmission.**

**Proposal 19: Support PUCCH cell switching for all UCI types.**

**Proposal 20: A UE is separately provided a *pucch-Config* for each BWP of the PUCCH SCell.**

**Proposal 21: Maintain PUSCH reception robustness due to multiplexing 1-2 HARQ-ACK bits from dynamic scheduling also when multiple HARQ-ACK bits from SPS PDSCH receptions are multiplexed in the PUSCH.**

**Proposal 22: Remove duplicated HARQ-ACK information from the Type-1 HARQ-ACK codebook for intra slot PDSCH repetition.**

**Proposal 23: The HARQ-ACK timing indicator counts only slots with PUCCH resources.**

The following are observations in this contribution.

***Observation 1****: If a Type-3 CB is associated with a priority, there is no need to differentiate LP HARQ-ACK and HP HARQ-ACK, particularly for an “enhanced” Type-3 CB of Rel-17.*

***Observation 2****: RRC configuration suffices for determining a triggered “enhanced” Type-3 HARQ-ACK codebook size.*

***Observation 3****: Consideration of only activated cells or of only cells with non-dormant active DL BWPs, instead of configured cells, is a general issue for constructing Type-1/Type-3 HARQ-ACK codebooks, and for partitioning PDCCH candidates/CCEs among scheduling cells, and should not be considered in isolation for a Type-3 HARQ-ACK codebook.*

***Observation 4****: RRC configured PUCCH cell timing pattern is sufficient to determine the cell of PUCCH transmission, regardless of SCS, and to support SPS HARQ-ACK deferral.*

***Observation 5****: A UE should not expect to be indicated by separate DCI formats to transmit PUCCHs in overlapping slots of different cells.*

### R1-2106962 UE feedback enhancements for HARQ-ACK CATT

***Proposal 1: Whether SPS HARQ-ACK should be deferred*** ***is determined based on the PUCCH resource for SPS HARQ-ACK only regardless of whether there are HARQ-ACK(s)*** ***corresponding to dynamic PDSCH and/or SPS PDSCH release to be transmitted in the same slot/sub-slot.***

***Proposal 2: If an initial PUCCH resource for SPS HARQ-ACK only in a slot indicated by K1 is not available, the SPS HARQ-ACK should be deferred to a slot in which the initial PUCCH resource is available.***

***Proposal 3: For multiplexing of deferred HARQ-ACK and initial HARQ-ACK, the HARQ-ACKs for deferred SPS HARQ-ACK are appended to the initial HARQ-ACKs.***

* ***FFS for optimizations for Type-1 HARQ-ACK codebook.***

***Proposal 4: PUCCH resource for multiplexing the deferred SPS HARQ-ACK and initial SPS HARQ-ACK (which is not deferred) or dynamic HARQ-ACK is determined based on the total number of HARQ-ACK bits following Rel-16 rules.***

***Proposal 5: The target slot/sub-slot for SPS HARQ-ACK deferral is not changed after determination.***

***Proposal 6: Confirm the working assumption that at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16) in Rel-17 is supported.***

***Proposal 7: Enhanced Type-3 codebook which includes HARQ-ACKs for HARQ processes of SPS PDSCHs only is supported.***

***Proposal 8: Type-3 codebook and enhanced Type-3 codebook are distinguished by RRC configuration only.***

***Proposal 9: The PHY priority indicated in triggering DCI is used to determine the priority of the PUCCH resource used for the enhance Type-3 codebook and the enhanced Type-3 codebook is constructed independently from the PHY priority indication.***

***Proposal 10: An additional DCI field can be added in DCI format 1\_2 to trigger (enhanced) Type-3 codebook.***

***Proposal 11: Confirm the working assumption that one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB in Rel-17 is supported.***

***Proposal 12: For one-shot triggering of dropped HARQ-ACK, the offset between the slot for triggering DCI and slot with dropped HARQ-ACK can be indicated by the triggering DCI to identify which ‘dropped HARQ-ACK’ should be re-transmitted.***

***Proposal 13: For one-shot triggering of dropped HARQ-ACK, the retransmitted HARQ-ACK bits can be appended to the initial HARQ-ACK codebook.***

***Proposal 14: For PUCCH carrier switching based on dynamic indication in DCI, SPS HARQ-ACK can be multiplexed with dynamic HARQ-ACK in the same slot if dynamic HARQ-ACK is indicated to be transmitted on the switched cell and the other configured PUCCH resources can be dropped if they are in the same slot with the switched dynamic HARQ-ACK;***

* ***For the case of different numerologies, the slot based the smallest SCS can be used as the reference slot.***

***Proposal 15: For PUCCH carrier switching based on semi-static RRC configuration, the granularity of switching pattern should be determined based on the slot of the PUCCH cell with smallest SCS configuration.***

***Proposal 16: For PUCCH carrier switching based on semi-static RRC configuration,***

* ***the PUCCH resource for dynamic HARQ-ACK on target SCell is determined by PRI indication and PUCCH resource configuration on SCell;***
* ***semi-static PUCCH resource on target SCell is determined by dedicated PUCCH resource configured for the target SCell.***

***Proposal 17: For the case of different SCS configurations between PUCCH carriers,***

* ***In case the PCell has larger SCS, multiplexing HARQ-ACKs in different slots on PCell to a PUCCH on SCell should be avoided by gNB;***
* ***In case the PCell has smaller SCS, PUCCH resource should be mapped to the first slot/sub-slot on the target SCell overlapping with the slot on PCell for PUCCH transmission.***

***Proposal 18: For joint operation of dynamic and semi-static PUCCH carrier switching, it is not expected that the target PUCCH cell determined based on dynamic indication in DCI is different from the PUCCH cell determined by switching pattern configured for semi-static PUCCH carrier switching scheme.***

***Proposal 19: If joint operation of PUCCH carrier switching and SPS HARQ-ACK deferral is supported, it is preferred to perform PUCCH carrier switching first.***

***Proposal 20: The maximum number of cells for PUCCH carrier switching is two.***

***Proposal 21: Configuring the PUCCH repetition factor per PUCCH resource can be applied for both slot and sub-slot based PUCCH.***

***Proposal 22: Configuring the PUCCH repetition factor per PUCCH resource can be applied for all UCI types.***

***Proposal 23: For sub-slot based Type-1 HARQ-ACK codebook, the PDSCH TDRA grouping should be performed per DL slot.***

### R1-2107025 Discussion on UE feedback enhancements for HARQ-ACK Panasonic

**Proposal 1: The SPS HARQ-ACK deferral should be configured per SPS configuration.**

**Proposal 2: On the condition of SPS HARQ-ACK deferral, following Alt.1 should be supported. Our second preference is the following modification of Alt.1A.**

* **Alt.1: Deferral only, if the SPS HARQ-ACK in the initial slot/sub-slot cannot be transmitted as the resulting PUCCH resource for transmission using the PUCCH by SPS-PUCCH-AN-List-r16 or n1PUCCH-AN is not valid.**
  + **If SPS HARQ-ACK is multiplexed with any other UCI / dynamic PUCCH resource, then it cannot be deferred.**
* **Alt.1A: Deferral only, if the PUCCH resource configured by SPS-PUCCH-AN-List-r16 or n1PUCCH-AN for the HARQ-ACK transmission assuming SPS HARQ-ACK only is not valid in the initial slot/sub-slot.**
  + **If SPS HARQ-ACK PUCCH resource is overlapping, it will be deferred even though it could still be multiplexed e.g., due to PRI overriding.**

**Proposal 3: Even if all SPS HARQ-ACK bits are not able to be sent in the PUCCH, the SPS HARQ-ACK bits should be transmitted as much as possible utilizing full capability of selected PUCCH format instead of dropping SPS HARQ-ACK bits.**

**Proposal 4: The codebook size of triggered Type-3 HARQ-ACK codebook is determined by RRC configuration and/or activation.**

**Proposal 5: DCI format 1-2 supports triggering Rel.16 Type 3 HARQ-ACK codebook and Rel.17 enhanced Type 3 codebook with smaller size**

**Proposal 6: PHY priority is supported for Rel.16 Type 3 HARQ-ACK codebook and Rel.17 enhanced Type 3 codebook with smaller size. The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Type 3 HARQ-ACK codebook.**

**Proposal 7: For one-shot triggering of HARQ-ACK retransmission on a PUCCH, the HARQ-ACK codebook to be retransmitted is explicitly indicated in the triggering DCI.**

**Proposal 8: For dynamic repetition factor indication for sub-slot-based PUCCH, the method to be specified in CovEnh WI for slot-based PUCCH repetition is directly applied to sub-slot PUCCH.**

**Proposal 9: For sub-slot-based PUCCH, both semi-static based PUCCH repetition factor “nrofSlots’ and dynamic based PUCCH repetition factor ‘nrofSlots-r17’ should be supported if sub-slot-based PUCCH repetition and dynamic repetition indication are separate UE features.**

**Proposal 10: Dynamic and semi-static PUCCH carrier switching should be configured and enabled for dynamic scheduling and SPS separately.**

**Proposal 11: For dynamic PUCCH carrier switching, the target carrier can be derived from the PRI field. To enlarge PRI field should be considered.**

**Proposal 12: Configure additional timing offset values for PDSCH to HARQ-ACK for the PUCCH carries.**

**Proposal 13: To enable dynamic and semi-static PUCCH carrier switching schemes simultaneously, one of the alternatives should be considered**

* **a dedicated indication can be configured in DCI for switching between two schemes,**
* **the semi-static carrier switching is applied when the PUCCH transmission is not possible over the dynamic indicated carrier.**

**Proposal 14: When semi-static carrier switching is enabled along with the SPS HARQ-ACK deferral, the UE should first apply HARQ-ACK deferral according to the PCell and then identifies the PUCCH carrier accordingly.**

### R1-2107133 Discussion on UE feedback enhancements for HARQ-ACK China Telecom

**Proposal 1: Whether the SPS HARQ-ACK is subject to deferral is jointly configured by RRC per PUCCH cell group.**

**Proposal 2: Inter-slot/sub-slot deferral happens when there is no available PUCCH resource with valid symbols in the initial slot/sub-slot.**

**Proposal 3: When SPS HARQ-ACK is deferred to available PUCCH resource, load balance should be considered when determining the available resource.**

* **If the payload/ code rate on a PUCCH resource is larger than a payload/ code rate threshold, the PUCCH resource is not available.**

**Proposal 4: For PUCCH carrier switching based on RRC configured PUCCH cell timing pattern, RRC configures a time unit and a period with the smallest SCS of the candidate PUCCH carriers as the reference SCS. The carrier configured for the time unit containing the slot/sub-slot determined by K1 is used for PUCCH transmission. The reference SCS for K1 is the SCS of Pcell/PScell/PUCCH-SCell.**

### R1-2107156 UE feedback enhancements for HARQ-ACK NEC

**Proposal 1:**

* *Support Type-1 HARQ-ACK codebook construction for sub-slot PUCCH configuration based on PDSCH TDRA grouping per DL sub-slot.*

**Proposal 2:**

* *Further study the HARQ-ACK location determination for SPS release in the Type-1 HARQ-ACK codebook based on sub-slot PUCCH configuration.*

**Proposal 3:**

* *HARQ-ACK bits will only be present in the semi-static type-1 codebook if the corresponding sub-slot has at least one PDCCH transmission or SPS PDSCH reception.*

**Proposal 4:**

* *Support deferral only, if the SPS HARQ-ACK in the initial slot/sub-slot cannot be transmitted as the resulting PUCCH resource for transmission using the PUCCH by SPS-PUCCH-AN-List-r16 or n1PUCCH-AN is not valid.*

**Proposal 5:**

* *Support multiplexing the deferred HARQ-ACK for SPS PDSCH and HARQ-ACK for dynamically scheduled PDSCH(s) on a Type-1 HARQ-ACK codebook.*
  + *Append the deferred HARQ-ACK bits for SPS PDSCH(s) after the HARQ-ACK codebook for dynamically scheduled PDSCH(s) If the value of k1eff for SPS HARQ-ACK is not in the configured K1 set.*

**Proposal 6:**

* *Confirm the working assumption to support retransmission of cancelled HARQ-ACK in Rel-17.*

**Proposal 7:**

* *Support dynamic triggering of an enhanced Type-3 CB of HARQ-ACK re-transmission for SPS PDSCH only.*
  + *Following alternatives can be considered to reduce the HARQ-ACK codebook size:*
    - *Alt.1: The requested HARQ-ACK codebook contains the number of all DL HARQ processes for all the configured/activated SPS configuration(s) in the configured CC(s).*
    - *Alt.2: The requested HARQ-ACK codebook contains only the number of DL HARQ processes for the indicated SPS configuration(s) in the configured CC(s).*
    - *Alt.3: The requested HARQ-ACK codebook contains a set of DL HARQ processes for the configured/activated SPS configuration(s) in the configured CC(s).*

**Proposal 8:**

* *For one-shot triggering of HARQ-ACK retransmission on a PUCCH resource in Rel-17, support multiplexing of retransmitted HARQ-ACK and initial HARQ-ACK.* 
  + *Further study how to multiplex retransmitted HARQ-ACK and initial HARQ-ACK on Type-1 HARQ-ACK codebook and Type-2 HARQ-ACK codebook.*

**Proposal 9:**

* *Supporting joint operation of dynamic and semi-static carrier switching for a UE is slightly preferred.*

**Proposal 10:**

* *Support the numerology associated with the largest SCS of the involved candidate cells as the reference numerology for the definition of the time domain pattern of semi-static PUCCH carrier switching.*
* *Support a UL slot as the time granularity for the time domain pattern of semi-static PUCCH carrier switching.*

**Proposal 11:**

* *For semi-static PUCCH carrier switching, further study how to determine the slots/sub-slots and target cell for PUCCH repetition transmissions.*

**Proposal 12:**

* *For dynamic PUCCH carrier switching, in case PUCCH on a CC for SPS HARQ-ACK is overlapped with the PUCCH on another CC for dynamic scheduled HARQ-ACK in time domain, support multiplexing SPS HARQ-ACK and DG HARQ-ACK on the PUCCH resource for DG HARQ-ACK.*
  + *FFS the Type-1 HARQ-ACK codebook construction for multiplexing SPS HARQ-ACK and DG HARQ-ACK.*

**Proposal 13:**

* *Support joint operation of dynamic PUCCH carrier switching and SPS HARQ-ACK deferral.*
  + *When the joint operation is configured, PUCCH carrier switching for SPS HARQ-ACK has priority over SPS HARQ-ACK deferral.*

**Proposal 14:**

* *Further study the PUCCH power control for PUCCH carrier switching.*

**Proposal 15:**

* *Further study how to configure PUCCH resource for a set of candidate cells for PUCCH carrier switching.*

### R1-2107180 HARQ-ACK feedback enhancement for IIoT/URLLC Lenovo, Motorola Mobility

**Proposal 1: A UE defers HARQ-ACK, if a corresponding HARQ-ACK codebook consists of only HARQ-ACK information for SPS PDSCH(s) without a corresponding PDCCH(s).**

**Observation 1: For Type-1 (i.e. semi-static) HARQ-ACK codebook, the Rel-15/16 codebook construction method is not directly applicable to deferred HARQ-ACK (i.e. K1 value for PDSCH-to-HARQ feedback timing needs to be redefined).**

**Observation 2: For Type-2 (i.e. dynamic) HARQ-ACK codebook, deferred SPS PDSCH HARQ-ACK bits may need to be re-ordered, if additional SPS PDSCH HARQ-ACK bits are multiplexed in a newly determined PUCCH resource.**

**Proposal 2: Support deferred HARQ-ACK transmission with concatenation of a delayed HARQ-ACK codebook and a current scheduled HARQ-ACK codebook to construct an aggregated HARQ-ACK codebook.**

**Proposal 3: DCI triggering HARQ-ACK retransmission includes** **information of cancelled HARQ-ACK transmission occasions for retransmission, e.g. a number of cancelled HARQ-ACK codebooks to be included for retransmission and timing information of the cancelled HARQ-ACK transmission occasions.**

**Proposal 4: Support implicit triggering of HARQ-ACK retransmission based on indication of two HARQ-ACK transmission occasions in DCI.**

**Proposal 5: Support autonomous one-shot HARQ-ACK re-transmission for all or a subset of HARQ processes in a CG-PUSCH resource, where the CG-PUSCH is available in an earlier slot/sub-slot than a slot/sub-slot where the earliest available PUCCH resource for HARQ-ACK is.**

### R1-2107272 HARQ-ACK enhancements for Rel-17 URLLC/IIoT OPPO

***Proposal 1: SPS HARQ-ACK deferral should be configured by RRC per SPS configuration.***

***Proposal 2: The maximum value of the total PDSCH to HARQ-ACK delay/offset, i.e. k1+k1def, of one SPS configuration is same as the maximum value of K1 set corresponding to the DCI format used to activate the SPS configuration.***

***Proposal 3: When both SPS HARQ-ACK deferral and PUCCH repetition are configured, for a SPS PDSCH reception ending in slot/subslot n, if the first PUCCH occasion is no later than slot/subslot n+k1+k1def,***

* ***if the last PUCCH occasion is no later than slot/subslot n+k1+k1def, a UE transmits the PUCCH as Rel-15/16;***
* ***otherwise, the UE transmits the PUCCH repetition(s) no later than slot/subslot n+k1+k1def and cancels the PUCCH repetition(s) after slot/subslot n+k1+k1def.***

***Proposal 4: Deferral should be before multiplexing decision.***

***Proposal 5: To determine the target slot/subslot for deferring SPS HARQ-ACK, starting from the initial slot/subslot,***

* ***Deferral only, if the SPS HARQ-ACK in one slot/sub-slot cannot be transmitted as the resulting PUCCH resource for transmission using the PUCCH by SPS-PUCCH-AN-List-r16 or n1PUCCH-AN is not valid.***

***Proposal 6:*** ***SPS PUCCH resources carrying N bits can be used as the candidates to check the validity of a SPS PUCCH resource for M-bit SPS HARQ-ACK associated to a slot, where N≥M.***

***Proposal 7: To check the validity of a slot for deferral of SPS HARQ-ACK,***

* ***If a PUCCH resource A, determined based on all SPS HARQ-ACKs associated to the slot, is not valid, and a PUCCH resource B, determined based on urgent SPS HARQ-ACKs (i.e. HARQ-ACKs for the SPS PDSCH with the maximum value of k1+ k1def and/or*** ***SPS PDSCH not configured with SPS deferral), is valid, the UE transmits the urgent SPS HARQ-ACKs in the slot;***
* ***Otherwise, check the validity of next slot for deferral.***

***Proposal 8: At least one subset of serving cells is configured by RRC, and DCI indicates one subset for enhanced Type 3 HARQ-ACK feedback.***

***Proposal 9: Self-carrier triggering for enhanced Type 3 HARQ-ACK CB can be supported as a special case, i.e. a DCI used to schedule cell X can only trigger an enhanced Type 3 HARQ-ACK CB contains the HARQ-ACKs for the HARQ processes on cell X.***

***Proposal 10: If multiple enhanced Type 3 HARQ-ACK CBs constructed based on different subsets are triggered in one slot/subslot, an enhanced Type 3 HARQ-ACK CB containing the HARQ-ACKs constructed based on the union of multiple subsets should be transmitted in the slot/subslot.***

***Proposal 11:*** ***Implicit indication of a retransmitted HARQ-ACK CB for one-shot*** ***triggering of HARQ-ACK retransmission on a PUCCH resource can be considered.***

***Proposal 12: To determine a set of occasions for candidate PDSCH receptions for subslot-based Type-1 HARQ-ACK CB:***

* ***Step 1: Determine candidate DL subslots corresponding to one UL subslot based on the K1 set.***
* ***Step 2: If the last symbol of a PDSCH TDRA row r is not in the candidate DL subslots, row r is removed from the candidates of TDRA rows.***
* ***Step 3: Determine occasions for candidate PDSCH receptions based on the remaining PDSCH TDRA rows.***

***Proposal 13: To support PUCCH carrier switching***

* ***At most 2 PUCCH cells for PUCCH carrier switching can be configured to one UE.***
* ***Dynamic carrier switching or semi-static carrier switching can be configured,*** 
  + - ***Additional*** ***enhancement on joint operation, including joint operation between dynamic carrier switching and semi-static carrier switching, and joint operation between carrier switching and SPS HARQ-ACK deferral is not supported.***

### R1-2107296 Discussion on UE feedback enhancements for HARQ-ACK FGI, Asia Pacific Telecom

Proposal 1 k1eff,max is configured per SPS configuration.

Proposal 2 The size of SPS HARQ-ACK codebook in a slot should be determined based on the number of non-deferred SPS HARQ-ACK bits and the number of SPS HARQ-ACK bits that may be deferred to the slot.

Proposal 3 Support triggering a Type-3 HARQ-ACK codebook by DCI format 1\_1 and DCI format 1\_2.

Proposal 4 When the priority indicator in a DCI triggering a Type-3 HARQ-ACK codebook indicates a PUCCH of low priority or a PUCCH of high priority, the PUCCH resource for the Type-3 HARQ-ACK codebook should be selected based on the payload size of the Type-3 HARQ-ACK codebook and the PRI in the triggering DCI, from the PUCCH resources configured in the first PUCCH-Config or in the second PUCCH-Config, respectively..

Proposal 5 A list of pdsch-HARQ-ACK-OneShotFeedbackCBG-r16 is used to indicate the presence of CBG HARQ-ACK bits in the Type-3 HARQ-ACK codebooks triggered by DCI formats indicating low priority and high priority.

Proposal 6 A list of pdsch-HARQ-ACK-OneShotFeedbackNDI-r16 is used to indicate the presence of NDI bits in the Type-3 HARQ-ACK codebooks triggered by DCI formats indicating low priority and high priority.

Proposal 7 For RRC configured PUCCH cell timing pattern, the information included in the pattern should be specified.

Proposal 8 The PUCCH cell timing pattern configuration can contain sets of bits with each set of bits indicating the target cell for each slot within a period. The PUCCH cell timing pattern configuration can contain periodicity to determine how may slots the PUCCH cell timing pattern are indicated. The PUCCH cell timing pattern configuration can contain a duration to indicate the time duration within it the PUCCH cell timing pattern is repeatedly applied.

Proposal 9 Mutiple PUCCH cell timing pattern can be configured, and each PUCCH cell timing pattern can have an associated index which can be indicated dynamically for faster switching between different patterns.

Proposal 10 Either a configurable maximum number of PUCCH cells or not setting a limit on maximum number of PUCCH cells is preferred.

Proposal 11 Applying semi-static carrier switching to all slots as basis and further changing the indicated PUCCH carrier for a slot by DCI can be considered.

### R1-2107336 HARQ-ACK enhancement for IOT and URLLC Qualcomm Incorporated

***Observation 1: Deferring SPS PUCCH A/N to “1st available PUCCH resource” does not always guarantee that the 1st available PUCCH resource is indeed available. This is a valid argument in cases of multiple SPS HARQ deferrals; presence of other HARQ bits, either for DG traffic or for non-deferred HARQ bits. In order to avoid collisions with other PUCCHs or PUSCHs for other UEs, which might lead to HARQ bits dropping or to further deferral, other mechanism controlled by the network are needed.***

***Observation 2: In a well planned radio access network, SPS PUCCH HARQ deferrals should not happen; if they happen, this is going to be an unusual case and several UEs in the cell will be affected.***

***Observation 3: The scenario of cancelling PUSCH and piggybacked HARQ bits is a strong case in URLLC scenarios.***

***Observation 4: The scenario of the UE internally dropping/cancelling LP PUCCH due to own HP PUCCH although theoretically possible should not be the driver for the work for cancelled/dropped HARQ bits in URLLC.***

***Observation 5: The work in specifying solutions for the scenario of SPS PUCCH HARQ bits colliding with DL symbols was initiated without any direct reference to any URLLC/IIOT scenario among the ones of TS 22.104.***

In summary, we make the following proposals for HARQ-ACK feedback enhancement for Rel-17 IOT and URLLC.

***Proposal 1: SPS HARQ-ACK deferral to the 1st available PUCCH should be configured per SPS configuration. If a PUCCH transmission consists of HARQ-ACK for at least one SPS configuration with deferral, the PUCCH transmission is deferred to the 1st available PUCCH.***

***Proposal 2: Maximum deferral value is configured at RRC per SPS configuration. UE will not retransmit the collided A/N bit after k1\_def\_max slots from the end of the slot where SPS A/N PUCCH collision happens.***

* ***In case of a PUCCH transmission containing HARQ-ACK bits from different SPS configurations with different maximum deferral values, the maximum of those maximum deferral values is applied.***

***Proposal 3: If a PUCCH for SPS HARQ ACK info is dropped due to overlapping with DL or flexible symbol indicated by dynamic SFI, the “SPS HARQ ACK deferral to 1st available PUCCH” will not be applied to this case, i.e. no further deferral for this dropped PUCCH.***

***Proposal 4: Multiplexing of DG UCI with SPS PUCCH HARQ-ACK in a PUCCH PRI which then collides with semi-static DL symbols, SSB, or CORESET#0 is handled as error case by the UE.***

***Proposal 5: When the colliding PUCCH contains both SPS HARQ and CSI, only SPS HARQ-ACK is deferred to the 1st available PUCCH and CSI is dropped.***

***Proposal 6: Upon “SPS PUCCH HARQ deferral to 1st available PUCCH resource” consider intra-slot deferral before inter-slot deferral.***

***Proposal 7: If the selected PUCCH carrying deferred A/N bits overlaps with DL transmission-scheduled by DCI in the target slot or DL/flexible symbol indicated by DCI format 2\_0, UE drops the deferred A/N bits without their further deferral.***

***Proposal 8: Support that A/N bits from multiple collided PUCCHs CAN be deferred to the same new PUCCH.***

***The new CB in the new PUCCH is the concatenation of individual CBs originally from those collided PUCCHs based on their order in time.***

***Proposal 9: At least when there is no existing non-deferred UCI bit in a candidate target slot, and if that slot cannot accommodate the PUCCH selected for all collided A/N bits.***

* ***UE does not transmit any collided A/N bit in that slot. UE will continue to check next candidate slot for transmitting all collided A/N bits.***

***Proposal 10: In presence of existing non-deferred A/N bit(s) in the target slot, support that both collided and existing A/N bit(s) CAN be transmitted in the same PUCCH.***

* ***The new CB in the PUCCH is the concatenation of the CB for existing A/N bit(s) and the individual CB(s) originally from collided PUCCH(s).***

***Proposal 11: In presence of existing non-deferred A/N bit(s) for SPS in a candidate target slot, if that slot cannot accommodate the PUCCH selected to carry both existing and collided A/N bits.***

* ***UE does not transmit any A/N bit in that slot. UE will treat all existing and collided A/N bits as collided A/N bits and continue to check next candidate slot for transmitting all collided A/N bits that are not expired.***

***Proposal 12: On whether to allow partial deferral***

* ***Not support deferral of only part of A/N bits in collided PUCCH.***

***Proposal 13: If deferred SPS A/N and DG A/N are in the same target slot, support multiplex both SPS and DG A/N on the same PUCCH indicated by PRI as in R15/16.***

***Proposal 14:******For SPS HARQ collision with DL symbols, RAN 1 to study whether and how to support either:***

* ***“SPS PUCCH HARQ deferral to 1st available PUCCH resource”, or***
* ***“PUCCH Carrier Switch” (in case of more than 1 PUCCH CCs), or***
* ***“1-shot Enhanced Type 3 CB HARQ”, or***
* ***Joint configuration of any of the above, whenever applicable.***

***Proposal 15:*** ***Upon joint configuration of any combination of “SPS PUCCH HARQ deferral to 1st available PUCCH resource”, “PUCCH carrier switching” and “1-shot Enhanced Type 3 CB HARQ”, execution of “SPS PUCCH HARQ deferral to 1st available PUCCH resource” starts immediately after the SPS PUCCH HARQ deferral triggering and it stops:***

* ***When appropriate PUCCH resource for the transmission of deferred HARQ is found, or***
* ***When a request for “1-shot Enhanced Type 3 CB” is received, or***
* ***When a “PUCCH-carrier switch command” is received in DCI (in case of more than 1 PUCCH CCs)***
* ***When the maximum value of “k1\_def” is reached***

***Proposal 16: “1-shot enhanced Type 3 CB”, is constructed with HARQ processes as basis and its contents are:***

* ***Either: all requested HARQ process IDs within a pre-determined time duration, td, with a starting point in time t0, e.g. t0: X sub(slots) prior to DCI, or***
* ***All requested HARQ Process IDs indicated in the DCI***

***Proposal 17: Only one Enhanced Type 3 CB size should be supported/requested within a given time duration.***

***Proposal 18: For the “one-shot triggering of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (second option of the working assumption):***

* ***support the transmission of only a single “cancelled HARQ-ACK CB” within a given time window***
* ***support gNB request for “UE Indication of Cancelled HARQ CB” in DCI 1\_1 or DCI 1\_2 with an extra bit.***
* ***support the indication of the UE of “cancelled HARQ” in UCI, only upon gNB request; “UE indication of cancelled HARQ” bit set to 1 upon existence of at least 1 “cancelled HARQ CB”.***

***Proposal 19: Support automatic transmission of a single cancelled HARQ ACK info at retransmission of PUSCH cancelled by DCI 2\_4.***

***Provided that DCI 0\_x indicates same NDI and HARQ Process ID for both cancelled and retransmitted PUSCH.***

***In case canceled UCI contains CSI, SR and HARQ payload, only HARQ payload is automatically transmitted.***

***No support for new UCI multiplexed in the retransmitted PUSCH.***

***Proposal 20: Do not support partial automatic (re)transmission of cancelled HARQ bits.***

***Proposal 21: Support automatic (re)transmission of 1 single dropped LP HARQ-ACK CB. Automatic (re)transmission at the same PRI as the one for the initial PUCCH allocation; PRI allocation valid for up to N slots.***

***Proposal 22: RAN 1 to study joint configuration of***

* ***automatic (re)transmission of cancelled/dropped HARQ-Ack,***
* ***“1-shot Enhanced Type 3 HARQ feedback”,***
* ***PUCCH carrier switching (in case of more than 1 PUCCH CCs)***

***Or of any combination of the above.***

***Proposal 23: Upon joint configuration of:***

* ***“automatic (re)transmission of cancelled/dropped HARQ-Ack”***
* ***“1-shot HARQ (re)transmission”***
* ***“PUCCH carrier switching”***

***Or of any combination of the above, execution of “automatic (re)transmission of dropped or cancelled HARQ-ACK” starts immediately after HARQ-ACK dropping or cancellation and it stops:***

1. ***when appropriate PUCCH resource for the transmission of the single dropped LP HARQ-ACK is found, or***
2. ***upon reception of PUSCH allocation (DCI 0\_x) with same NDI and HARQ ID(s) as the allocation of the initially cancelled PUSCH via DCI 2\_4 , or***
3. ***when a request for “1-shot HARQ (re)transmisison” is received, or***
4. ***when a “PUCCH-Carrier Switch Command” is received in DCI (in case of more than 1 PUCCH CCs)***
5. ***when the validity of the PUCCH Resource for the single dropped LP HARQ CB expires.***

***Proposal 24: For semi-static configured PUCCH carrier switch, use Pcell or PScell as the reference CC to interpret the K1 value and determine a reference slot for PUCCH transmission, then use Pcell or PScell as reference CC to interpret the carrier switch time pattern to determine the target cell for PUCCH transmission. If the target cell numerology is larger than Pcell or PScell, the earliest actual slot on the target cell which falls into the reference slot is used to transmit the PUCCH.***

***Proposal 25: In PUCCH power control, support separate P0 configuration for each of the cells with PUCCH carrier switch enabled.***

***Proposal 26: In PUCCH power control, support accumulating closed loop power control commands only within the same target cell by reusing Rel-15 procedure. Don’t support accumulating power control commands across cells.***

***Proposal 27: Support to use MAC-CE to signal PUCCH spatial relation on Scell(s) with PUCCH carrier switch. FFS details of such MAC-CE signalling including how to reduce the MAC-CE overhead.***

***Proposal 28: RAN1 to study then decide whether and how to support the following joint operations.***

* ***Joint operation of PUCCH carrier switch, parallel PUCCH/PUSCH transmission, and intra-UE multiplexing.***
* ***Joint operation of PUCCH carrier switch with PUCCH repetition.***
* ***Joint operation of PUCCH carrier switch with SPS A/N deferral.***

***Proposal 29: For sub-slot based Type-1 HARQ-ACK codebook construction in NR Rel-17, support TDRA grouping and pruning based on UL sub-slots.***

* ***More specifically, for each UL sub-slot , UE determines a set of TDRA candidates that ends in the UL sub-slot, and perform TDRA pruning based on the Rel-15 approach.***

### R1-2107397 Discussion on UE feeback enhancements for HARQ-ACK CMCC

***Proposal 1: PUCCH carrier switching is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells.***

***Proposal 2: The length of PUCCH switching configuration table equals to of the Pcell/PScell.***

***Proposal 3: The reference slot (like slot0 in the table) is based on Pcell/PScell.***

***Proposal 4: The corresponding slot number of other Scells is calculated according to slot offset configuration given by (TS38.211, 4.5 Carrier aggregation)***

### R1-2107443 Discussion on UE feedback enhancement for HARQ-ACK LG Electronics

Proposal 1: SPS HARQ-ACK deferral is configured per SPS configuration

Proposal 2: Alt. 2 for deferral condition is not supported.

Proposal 3: Alt. 1A for deferral condition is supported.

Proposal 4: To determine deferral of SPS HARQ-ACK in an initial slot/sub-slot, following alternative can be considered:

* Alt. 2: Defer if there is no available symbol for an uplink transmission obtained in case of UL multiplexing in the initial slot/sub-slot as if there are only semi-statically scheduled PUCCH transmission and PUCCH only for the SPS HARQ-ACK.

Proposal 5: For an initial slot/sub-slot of deferral, deferral procedure doesn’t make any changes on a result of UL multiplexing in the initial slot/sub-slot.

Proposal 6: To determine availability of candidates for target slot, the same assumption used to determine deferral can be considered.

Proposal 7: For SPS HARQ-ACK deferral, the target slot of deferral procedure is a slot/sub-slot where next SPS PUCCH occasion of corresponding SPS configuration is.

* FFS: whether to use SPS PUCCH occasion for different SPS configuration.

Proposal 8: Confirm above working assumption.

Proposal 9: For SPS HARQ-ACK deferral, the target slot of deferral procedure is next available slot/sub-slot n+k where reference PDSCH occasion is received in slot n and k is element of a set K.

* Reference PDSCH occasion is one of PDSCH occasion corresponding to deferred HARQ-ACK.
* The set K is union of configured sets of PDSCH-to-HARQ-ACK feedback timings.
* FFS: How to determine reference PDSCH for deferral

Proposal 10: Support type-3 HARQ-ACK codebook only for a part of HARQ process IDs and/or serving cells (e.g. the serving cells/HARQ process IDs configured for SPS PDSCH).

Proposal 11: if type-3 HARQ-ACK codebook is supported only for SPS PDSCH, it can be considered to separate the codebook for dynamic PDSCH and for SPS PDSCH.

Proposal 12: Support enhanced type-3 HARQ-ACK codebook with reduced HARQ-ACK payload size for re-transmission of cancelled HARQ-ACK if necessary.

Proposal 13: For construction of the enhanced type-3 HARQ-ACK codebook with reduced HARQ-ACK payload size, following options can be considered:

* Option 1: type-3 HARQ-ACK codebook with subset of entire HARQ processes.
  + Multiple subset of HARQ processes can be configured by RRC signaling.
  + A subset of HARQ processes can be indicated in a DCI triggering type-3 HARQ-ACK codebook for HARQ-ACK codebook construction.
* Option 2: type-3 HARQ-ACK codebook with HARQ processes used in SPS PDSCH reception.

Proposal 14: For triggering method enhanced type-3 HARQ-ACK codebook with reduced HARQ-ACK payload size, following options can be considered on the top of current framework. :

* + Option 1: triggering DCI indicates a subset of HARQ processes for the HARQ-ACK codebook. Existing DCI field (e.g., One-shot HARQ-ACK request field) can be re-used or extended for indicating a subset of HARQ process.
  + Option 2: RNTI scrambling CRC of DCI format can indicates how to construct type-3 HARQ-ACK codebook.

Proposal 15: For type-3 HARQ-ACK codebook only for SPS PDSCH, priority handling can be considered.

Proposal 16: Take interpretation 2 or 3 as one-shot triggering framework.

Proposal 17: Adopt above working assumption to sub-slot repetition if the working assumption is confirmed.

Proposal 18: Discuss whether to apply above working assumption to semi-static PUCCH and how repetition factor is applied in the case of UL multiplexing with semi-static PUCCH resource.

Proposal 19: Use 3-bit PRI field or adopt dedicated DCI field to indicate switched carrier.

Proposal 20: For HARQ-ACK PUCCH for SPS PDSCH itself, dynamic PUCCH carrier switching is not supported.

* Carrier indication in activation DCI is ignored for SPS PDSCH without corresponding DCI

Proposal 21: For PUCCH carrier switching based on semi-static indication, the PDSCH to HARQ-ACK offset k1 is interpreted based on the numerology of original PUCCH cell (i.e. primary cell).

Proposal 22: For PUCCH carrier switching based on semi-static indication, target PUCCH resource in the target cell can be determined with following:

* PRI or resource set ID is re-used in the target carrier.
* First UL slot overlapped with original UL slot or a symbol of original PUCCH can be used as target UL slot in the target carrier.

### R1-2107472 UE feedback enhancements for HARQ-ACK ETRI

Regarding HARQ-ACK deferral,

**Proposal 1: The SPS HARQ-ACK deferral can be configured per SPS configuration.**

**Proposal 2**: **In addition to semi-static DL/SSB/CORESET0, some of semi-static FL symbols can be invalid by configurations.**

**Proposal 3**: **The deferred SPS HARQ-ACK bits are prepended in the Type1 HARQ codebook.**

**Proposal 4**: **Further study the Type2 HARQ codebook if deferred SPS HARQ-ACK bits are present**

**Proposal 5: If being repeated, the PUCCH is transmitted within the latest effective time window in the HARQ codebook if applicable.**

Regarding Type-3 HARQ-ACK codebook,

**Proposal 6**: **The size of the enhanced Type-3 HARQ-ACK codebook can be determined by at least activation/release DCI for SPS.**

**Proposal 7**: **The size of the enhanced Type-3 HARQ-ACK codebook can be determined by at least activated serving cells.**

**Proposal 8**: **The reference time to derive HARQ-ACK codebook is introduced in terms of a (sub) slot, where the HARQ-ACK of relevant HARQ processes are involved.**

**Proposal 9**: **If M=2 type-3 HARQ-ACK codebooks are enabled, then the distinct RNTI can be used to generate a legacy one or an enhancement one.**

Regarding PUCCH carrier switching,

**Proposal 10: SPS HARQ-ACK deferral may not be configured if PUCCH cell switching is enabled.**

**Proposal 11: The maximum number of PUCCH cell can be the number of configured serving cells.**

**Proposal 12: Further study to change a serving cell for PUCCH transmission with repetition.**

**Proposal 13: Any UCI type can support the PUCCH carrier switching if supported.**

### R1-2107491 On UE feedback enhancements for HARQ-ACK MediaTek Inc.

1. ***Support the dynamic PUCCH carrier switching for scheduled PUCCH and support the semi-static PUCCH cell timing pattern for configured SPS HARQ-ACK PUCCH.***
2. ***Support of the dynamic indication in the triggering DCI by including a new DCI field for the carrier switching indication***
3. ***For PUCCH carrier switching based on semi-static PUCCH cell timing pattern, the reference numerology for the timing pattern is configurable by the gNB.***
4. ***For PUCCH carrier switching based on semi-static PUCCH cell timing pattern, the granularity of the timing pattern UL slot of the reference numerology.***
5. ***Define two levels of PUCCH configuration, “per PUCCH group” and “per PUCCH carrier”.***
6. ***Each cell carrying PUCCH has its own TPC configuration (PUCCH-PowerControl) and has its own TPC loop. When switching the PUCCH carrier, UE changes the power control parameters to use the ones associated to the new PUCCH carrier.***
7. ***Explore the signalling and the support of one-shot triggering:***

***Alt-1: a new DCI field to be introduced for signalling. E.g. a new single bit triggers re-sending, i.e., concatenation or e.g. slot index(-ices) pointing back in time selecting the codebook(s) that are requested for resending***

***Alt-2: existing DCI field is reused for signalling. E.g. pre-configured special value of K1 or combination of K1 and another field (e.g. HARQ) triggers re-sending, i.e. concatenation. Another possibility is to define a pre-configured special value of HARQ process ID (or special value in another field different from K1) that triggers re-sending, i.e. concatenation.***

***Alt-3: implicit signalling is used (based e.g. on RNTI, search space)***

***Alt-4: the sending is triggered implicitly by the earliest PUCCH that is transmitted next or after the current slot.***

1. ***The PHY priority in the triggering DCI triggers only HARQ-ACK of the same priority.***
2. ***Support enhanced Type 3 HARQ-ACK CB for the LP-HARQ and the one-shot triggering for HP-HARQ.***
3. ***An RRC configuration should be defined to enable/disable HARQ-ACK deferral per PUCCH cell group***
4. ***k1eff to not exceed the maximum value in the set of configured K1 values.***

### R1-2107583 Design aspects for the agreed HARQ feedback enhancements Intel Corporation

**Proposal 1-1**

* *SPS HARQ-ACK deferring is enabled/disabled by semi-static signaling per SPS configuration*

**Proposal 1-2**

* *Whether a SPS HARQ feedback should be deferred is determined solely based on semi-static configurations upon reception of SPS activation for any of the PDSCH activated by this DCI*
  + *I.e., dynamic UCI multiplexing/presence is not considered*
* *Support additional configuration of SPS PUCCH resource with activated deferring, which is used for hypothesis testing on mapping SPS HARQ-ACK bits for a given initial/deferred slot/sub-slot*

**Proposal 1-3**

* *For the activated SPS HARQ-ACK deferral, the maximum k1 value is configured by RRC*

**Proposal 1-4**

* *The working assumption on handling SPS HARQ process ID collision can be confirmed with clarification that “received PDSCH” cover both skipped and transmitted SPS PDSCH*

**Proposal 1-5**

* *Existing procedures for deferred SPS HARQ-ACK multiplexing on UCI are reused with additional handling of inclusion of a non-contained k1 value to the k1 set for Type 1 CB construction*

**Proposal 2-1**

* *Support triggering of Type 3 CB additionally by DCI format 1\_2*
* *Support triggering of eType 3 CB by DCI formats 1\_1 and 1\_2*

**Proposal 2-2**

* *Support triggering of enhanced Type 3 CB transmission by both*
  + *DCI scheduling other PDSCH*
  + *DCI not scheduling other PDSCH*

**Proposal 2-3**

* *Support combination of RRC configuration and triggering DCI content for constructing enhanced Type 3 CB, i.e. support multiple Type 3 CB sizes*
  + *The different CB sizes are resulted from different assumption on*
    - *cells to be reported*
    - *SPS-only or all HARQ processes*
    - *priority*
    - *etc.*

**Proposal 2-4**

* *When Type 3 or eType 3 CB is triggered by a DCI, the priority field in the DCI, if present, is used to determine PUCCH priority carrying the CB*

**Proposal 2-5**

* *Support enhanced Type 3 CB construction from a subset of HARQ processes based dynamic indication in DCI triggering the enhanced Type 3 CB*
  + *FFS details*

**Proposal 2-6**

* *For handling HARQ feedbacks which process IDs are not included into the sub-set requested by a eType 3 CB trigger*
  + *Option 1: a UE is not expected the sub-set of HARQ IDs to not contain the new HARQ feedback*
  + *Option 2: a UE drops the HARQ feedback if the corresponding process ID is not contained in the triggered sub-set*

**Proposal 3-1**

* *For sub-slot PUCCH repetition, introduce a mechanism of skipping UL symbols during repetitions mapping*
  + *Alt.1: X-symbol gap*
  + *Alt.2: Y-sub-slot gap*
  + *Alt.3: Invalid symbol pattern*

**Proposal 3-2**

* *The number of REs for UCI carrying HARQ-ACK on PUSCH is scaled with the number of PUCCH repetitions overlapped with a PUSCH*
  + *FFS details*

**Proposal 3-3**

* *RAN1 uses the same mechanism for dynamic indication of the number of PUCCH repetitions for slot-based and sub-slot-based operation, by aligning with decisions made in CovEnh*

**Proposal 4-1**

* *For dynamic PUCCH carrier indication in DCI, the definition of PUCCH Resource ID (PRI) is extended by indicating a pair of {PUCCH resource, PUCCH carrier}*

**Proposal 4-2**

* *For dynamic PUCCH carrier indication in DCI, limit the UCI information for switching to HARQ-ACK and SR (when multiplexed with HARQ-ACK)*

**Proposal 4-3**

* *If a time pattern for PUCCH for semi-static HARQ-ACK is not provided, the semi-static HARQ-ACK is multiplexed with dynamic HARQ-ACK on the carrier indicated for dynamic HARQ-ACK*
  + *FFS if a time pattern for PCCH for semi-static HARQ is provided*

### R1-2107639 HARQ enhancements for IIoT and URLLC InterDigital, Inc.

***Proposal 1:*** *Support PHY priority handling for the enhanced Type 3 HARQ CB.*

***Proposal 2:*** *The DCI triggering enhanced Type 3 CB can indicate the priority of the Type 3 HARQ CB.*

***Proposal 3:*** *Support at least**a non-scheduling DCI triggering the one-shot HARQ-ACK retransmission.*

***Proposal 4:*** *The UE expects the same PUCCH carrier indication for all the scheduled A/Ns associated with the same HARQ-ACK codebook.*

***Proposal 5:*** *The UE selects the PUCCH carrier based on the carrier index in case more than one PUCCH carrier are available.*

### R1-2107732 HARQ Feedback Enhancements for URLLC Apple

**Proposal 2-1: to control feedback overhead, the presence of NDI and utilization of CBG based feedback can be separately configured for code states in the “priority indicator”.**

**Proposal 2-2: to control feedback overhead, HARQ process IDs can be grouped, one group is associated with the high priority, another is associated with the low priority.**

**Proposal 3-1: the number of PUCCH cells is limited to 2 for both dynamic indication and semi-static configuration.**

**Proposal 3-2: semi-static time pattern for PUCCH cells provides potential resources for PUCCH transmission. Transmitting PUCCH over a potential resource is subject to the same rules for PUCCH over a single CC case, in terms of semi-static SFI and dynamic SFI and dynamic scheduling.**

**Proposal 3-2: nested PUCCH symbols are not allowed for PUCCH carrier switching.**

**Proposal 3-3: out-of-order HARQ-ACK remains forbidden for non-mTRP scenarios with PUCCH carrier switching.**

### R1-2107791 UE feedback enhancements for HARQ-ACK Sharp

**Proposal 1:**

* The deferring of SPS HARQ-ACK dropped due to TDD specific collisions is configured by RRC per SPS configuration.

**Proposal 2:**

* **‘NACK skipping’ for (skipped) SPS PDSCH is supported**.

**Proposal 3:**

* **‘HARQ bundling’ for (non-skipped) SPS PDSCH is supported**.

**Proposal 4:**

* **PUCCH repetition for PUCCH formats 0 and 2 is also supported for slot based PUCCH repetition in Rel-17**.

**Proposal 5:**

* **Sub-slot based PUCCH repetition for other UCI types (than HARQ-ACK) is also supported**.

**Proposal 6:**

* Clarify the necessary modifications on Type-3 HARQ-ACK codebook for adoption in Rel-17 URLLC operation first, e.g., handling of different priorities.

### R1-2107833 UE feedback enhancements for HARQ-ACK TCL Communication Ltd.

**Proposal 1: The SPS HARQ-ACK deferral should be configured per SPS configuration.**

**Proposal 2: The PUCCH which carries the deferred HARQ-ACK feedback should be the first instance of PUCCH which does not collide with any invalid or downlink symbols and this PUCCH resource should not be restricted to the PUCCH for SPS only.**

**Proposal 3: Only if the intra-slot deferral cannot be achieved, and then inter-slot deferral should be considered.**

**Proposal 4: To determine an available PUCCH resource for conveying the deferred SPS HARQ-ACK,semi-static flexible symbol(s) could be used for transmitting the deferred HARQ-ACK feedbacks.**

**Proposal 5: The *k1def,max*. should be the maximum k1 value of the configured K1 set.**

**Proposal 6: The value of *k1eff* should be limited to one of the existing k1 values in the configured K1 set**

**Proposal 7: Enhanced Type 3 HARQ-ACK CB with smaller size in Release-17 should be supported.**

**Proposal 8： ACK skipping and/or NACK skipping mechanism for shorter SPS periodicity or multiple SPS configurations should be supported.**

**Proposal 9： HARQ bundling/compression should be supported for HARQ-ACK payload reduction and N-bits SPS HARQ-ACK should be bundled into one single bit using logical ‘OR’.**

**Proposal 10: The PDSCH TDRA grouping should be performed per sub-slot.**

### R1-2107851 Discussion on HARQ-ACK feedback enhancements for Rel.17 URLLC NTT DOCOMO, INC.

Proposal 1: Support option 1, i.e. joint RRC configuration of the SPS HARQ-ACK deferral per PUCCH cell group.

Proposal 2: Support Alt. 1. Deferral only, if the SPS HARQ-ACK in the initial slot/sub-slot cannot be transmitted as the resulting PUCCH resource for transmission using the PUCCH by SPS-PUCCH-AN-List-r16 or n1PUCCH-AN is not valid, where the “invalid” symbol stands for semi-static DL or SSB symbol.

Proposal 3: For definition of “next available PUCCH resource”,

* The “next available PUCCH resource” is the PUCCH resource in the earliest sub-slot/slot after the K1 indicated sub-slot/slot considering at least following conditions:
  + **Maximum effective K1 limitation is configured per SPS configuration.**
  + **the PUCCH for deferred HARQ-ACK transmission in the sub-slot/slot has no collision with any semi-static DL symbol and SSB symbol.s**
* **Keep the UE behavior for deferred SPS HARQ-ACK aligned with that in initial slot/sub-slot.** 
  + **Candidate PUCCH resource for non-deferred SPS HARQ-ACK is PUCCH resource configured by SPS-PUCCH-AN-List-r16 or n1PUCCH-AN.**
  + **Intra-UE multiplexing is considered when determining target deferral slot/sub-slot.**

Proposal 4: For HARQ-ACK CB construction for SPS HARQ-ACK deferring

* **If UE reports only deferred SPS HARQ-ACK information in the HARQ-ACK CB, simply order deferred SPS HARQ-ACK bits.**
* **If UE reports non-deferred HARQ-ACK information and deferred SPS HARQ-ACK information in the HARQ-ACK CB, deferred SPS HARQ-ACK bits are appended after non-deferred bits.**
* **For ordering deferred SPS HARQ-ACK bits, Rel.16 SPS HARQ-ACK bit order principle as in clause 9.1.2 of TS38.213 can be the baseline, i.e. based on serving cell index, SPS configuration index, SPS PDSCH slot index.**

**Proposal 5: Confirm the working assumption for HARQ-ACK retransmission.**

**Proposal 6: If DCI 1\_1 can be simultaneously configured with one-shot HARQ-ACK feedback and priority indicator field existing in DCI 1\_1, type 3 HARQ-ACK CB consists of all HARQ process IDs regardless of priority indicated for each HARQ-ACK bit. The priority of the HARQ-ACK PUCCH is determined by physical priority indicator in the triggering DCI.**

**Proposal 7: Support the configuration with more than one enhanced type 3 HARQ-ACK CBs with smaller size. Triggering DCI indicates which type 3 HARQ-ACK CB to be reported.**

**Proposal 8: Support one-shot triggering of HARQ-ACK retransmission for all HARQ-ACKs in a time window.**

**Proposal 9: Support slot-based PUCCH repetition for PUCCH formats 0 and 2.**

**Proposal 10: Do not support sub-slot based PUCCH repetition for SR and CSI.**

Proposal 11: Support sub-sot based TDRA grouping/pruning for type 1 HARQ codebook for sub-slot based HARQ-ACK feedback in Rel.17.

**Proposal 12: A dedicated DCI field is used to indicate target PUCCH cell. UE doesn’t expect overlapping of HARQ-ACK slots indicated by DCI on different PUCCH cells.**

**Proposal 13: The dedicated target PUCCH cell is not applied for SPS HARQ-ACK if the field exists in the activation DCI. A default cell (e.g. PCell/PScell/PUCCH-Scell) is determined as the target PUCCH cell for SPS PDSCHs of all SPS configurations.**

**Proposal 14: If there is overlapping of SPS HARQ-ACK slot and dynamic HARQ-ACK slot on different PUCCH cells, SPS HARQ-ACK will be multiplexed to the dynamic HARQ-ACK slot on the target cell indicated by DCI. SPS HARQ-ACK CBs on other cells are appended after the original type 1/2 HARQ-ACK CB generated for the dynamic HARQ-ACK slot.**

**Proposal 15: For semi-static PUCCH carrier switching, the PUCCH cell timing pattern is defined based on the numerology of PCell/PScell/PUCCH-Scell. Slot-level granularity indication based on TDD configuration length will be applied.**

**Proposal 16: If SCS of target cell is different from the SCS of PCell/PScell/PUCCH-Scell,**

* **If SCS of target cell is larger than SCS of PCell/PScell/PUCCH-Scell, the slot overlapping with the PUCCH slot on PCell/PScell/PUCCH-Scell is the PUCCH slot after PUCCH carrier switching.**
* **If SCS of target cell is smaller than SCS of PCell/PScell/PUCCH-Scell, the first slot overlapping with the PUCCH slot on PCell/PScell/PUCCH-Scell is determined as the PUCCH slot after PUCCH carrier switching.**

### R1-2107917 UE feedback enhancements for HARQ-ACK Xiaomi

*Proposal 1: When multiplexing in initial slot is possible, HARQ-ACK should not be deferred.*

*Proposal 2: we support option 2, k1def*  *should be counted based on UL and S slots according to semi-static TDD pattern.*

*Proposal 3: Same SCS of PUCCH carriers within a PUCCH cell group should be highest priority, and other different SCS decrease priority from high SCS to low SCS.*

*Proposal 4: The case of multiplexing and collision should not be considered on the switching PUCCH carrier.*

*Proposal 5: Do not support out-of-order trigger and out-of-order HARQ feedback when switching PUCCH carrier.*

*Proposal 6: Dynamic repetition indication mechanism in CE PUCCH enhancement can be directly applied to sub-slot based PUCCH repetition.*

*Proposal 7: It is unnecessary to support slot-based PUCCH repetition for format 0 and 2.*

*Proposal 8: Support NACK skipping for skipped SPS PDSCH and support ACK skipping for non-skipped SPS PDSCH.*

*Proposal 9: Support using alt 4 HARQ bundling / compression combined with alt 1 and alt 3 together to achieve the most significant gain.*

*Proposal 10: Dynamic indication of skipped SPS is not necessary considering a tradeoff between small gains and large standard impacts.*

### R1-2108152 Discussion on HARQ-ACK enhancement for URLLC/IIoT WILUS Inc.

* *Proposal 1: When enhanced Type-3 HARQ-ACK CB with smaller size is used for at least HARQ-ACK retransmission, the following aspects should be further enhanced.*
  + *Support of DCI format 1\_2 triggering enhanced Type-3 HARQ-ACK CB, Determination on PHY priority of enhanced Type-3 HARQ-ACK CB, and Inclusion of HARQ-ACK of SPS release DCI*
* *Proposal 2: We propose to support Alt-2, i.e., the HARQ-ACK codebook to be re-tx is explicitly indicated in the triggering DCI for one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource for Rel-17 URLLC/IIoT.*

### R1-2108162 UE feedback enhancements for HARQ-ACK CAICT

***Proposal 1: SPS HARQ-ACK deferral is configured per SPS configuration.***

***Proposal 2: SPS HARQ-ACK is deferred if initial PUCCH includes invalid symbol(s) which the initial PUCCH is determined according to the current UCI multiplexing behavior from the configuration of SPS-PUCCH-AN-List-r16 or n1PUCCH-AN, n1PUCCH-AN, multi-CSI-PUCCH-ResourceList.***

***Proposal 3: If gNB supports PUCCH blind detection assuming DCI is missed by UE, SPS HARQ-ACK needs not to be deferred if it is transmitted in the initial PUCCH which is decided from PUCCH-ResourceSet. Otherwise, SPS HARQ-ACK should be deferred even if it is transmitted in the PUCCH from PUCCH-ResourceSet.***

***Proposal 4: SPS HARQ-ACK is possible to be deferred to one PUCCH other than the initial PUCCH in the initial slot/subslot.***

***Proposal 5: To decrease the deferred SPS HARQ-ACK impacts on the UCI in the initial PUCCH, if the initial PUCCH is invalid, UCI multiplexing procedure in the initial slot/subslot assumes bits of SPS HARQ-ACK is to be transmitted while bits of SPS HARQ-ACK is deferred to the following slots/subslots,***

* ***wherein, is the bit width of SPS HARQ-ACK in the initial PUCCH. bits of SPS HARQ-ACK within the bits is configured deferrable, . The value of is the minimum value that results in at least one valid PUCCH or PUSCH for the UCIs in the “initial PUCCH” according to the existing UCI multiplexing rules, .***

***Proposal 6: gNB configures whether UL symbols indicated by SFI could be valid symbols or not when deciding available PUCCH.***

***Proposal 7: The next available PUCCH is the earliest one within the PUCCHs decided within available symbols and the PUCCHs which was to be transmitted according to Rel.16 procedure.***

***Proposal 8: To decide the number of contiguous UL symbols for available PUCCH transmission, PUCCH parameters configured by n1PUCCH-AN/SPS-PUCCH-AN-List-r16 could be reused, or special PUCCH configuration for deferred HARQ-ACK could be considered.***

***Proposal 9: Semi-static configured PUCCH transmission according to SPS-PUCCH-AN-List-r16 or multi-CSI-PUCCH-ResourceList could be used as available PUCCH.***

***Proposal 10: gNB configures whether PUCCH transmission scheduled for dynamic HARQ-ACK could be used as available PUCCH or not.***

***Proposal 11: New bit field in DCI to indicate the target cell is acceptable if majority companies think it is feasible in Rel.17.***

***Proposal 12: Consider overlapped slots in other BWPs which includes SPS HARQ-ACK when constructs HARQ-ACK codebook in the target BWP.***

***Proposal 13: For Alt.1, PUCCH switching for SPS HARQ-ACK is achieved by dynamic /PUSCH scheduling in another cell.***

***Proposal 14: For Alt 2C, the time domain pattern is based on one reference slot and the reference slot corresponds to the lowest SCS of candidate BWPs.***

***Proposal 15: Construct HARQ-ACK codebook based on the reference slot and the numerology of reference BWP rather than based on the actual slot which the PUCCH is transmitted.***