**3GPP TSG-RAN WG1 Meeting #106bis-eR1-21XXXXX**

e-Meeting, Oct 11th – 19th, 2021

**Agenda item: 8.3.1.1**

**Source: Moderator (Nokia)**

**Title: Moderator summary #2 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:

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

* 1st check point: October 14
* Final check point: October 19

**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
* Section 7 describes further suggested enhancements by different companies not directly related to the agreed study focus based on previous RAN1 agreements
* Section 8 summarizes some of the inputs on the related RRC parameter discussions
* 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:

|  |
| --- |
| 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) / multiplexingAgreements:* 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**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** For SPS HARQ-ACK deferral, the maximum deferral value in terms of k1+k1def is RRC configured per SPS configuration.**Agreement**For SPS HARQ-ACK deferral, only SPS HARQ bits subject to deferral from HARQ-ACK codebook from an initial PUCCH slot are deferred to the target PUCCH slot**Agreement** 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 **Agreement**For SPS HARQ-ACK deferral, the target PUCCH slot is defined as the next PUCCH slot where *sps-PUCCH-AN-List-r16* or*n1PUCCH-AN* PUCCH resource is regarded as valid*,*or a 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
* 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.

**Agreement**For SPS HARQ-ACK deferral, if after the target PUCCH slot determination the deferred SPS HARQ-ACK cannot be transmitted, the deferred SPS HARQ-ACK bits are not further deferred and are dropped.**Agreement**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.**Agreement**For SPS HARQ-ACK deferral, confirm the RAN1#104b-e working assumption with the following updates in RED:(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 of DG PDSCH with the same HARQ process ID  |

* 1. Summary of companies input in their contributions

**Final details of initial slot handing:**

* For determining when to defer from the initial slot/sub-slot, only potential HARQ-ACK multiplexing is considered, and potential multiplexing between/among HARQ-ACK and other UCI type(s) is not considered: vivo [5] (see discussions there, not considering any UCI multiplexing in the ‘cannot be transmitted’)
	+ *Moderator comment*: *It seems that the intention had been (when taking the agreement) to consider the final multiplexing – but do agree that we did not really clarify this sufficiently (when doing the down-selection of the Alt. in the GTW session). For the target slot, this had been better described and at least should be clear in the target slot. Maybe some similar clarification could be added to the initial slot description*
* Reuse the legacy UCI multiplexing/prioritization rules to determine the final PUCCH/PUSCH transmission, as well as the conveyed UCI(s), if determined not to be deferred: vivo [5]
	+ *Moderator comment: if not having any contradicting decision/agreements, R16 rules should automatically apply!?*
* Multiplexing with CSI/SR (i.e., Rel-16 UCI multiplexing) should be performed before the SPS HARQ-ACK deferral decision in the initial slot (i.e., HARQ-ACK cannot be transmitted, as the…): CATT [9], Samsung [15], Qualcomm [27] (discuss mux on PUSCH)

**HARQ-ACK information subject to deferral:**

* Only SPS HARQ-ACK subject to deferral and have not reached the maximum deferral value are deferred to the next available PUCCH (other SPS HARQ-ACK is dropped): Huawei/His [1], Samsung [15], APT/FGI [22] – Discuss: LGE [25]
* Dropping partial SPS HARQ-ACKs for the purpose of re-determining a valid PUCCH resource should not be considered: Huawei/HiSi [1], Samsung [15] (?)
* A SPS HARQ-ACK bit in a HARQ-ACK codebook is set to NACK for transmission in a slot if the SPS HARQ-ACK bit was reported before the slot: FGI/APT [22]
	+ *Moderator comment*: Is there a need to still have a deferred SPS HARQ-ACK in a CB (and set to NACK) if the SPS HARQ-ACK has been deferred and transmitted already?

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

* Discuss if (CG/DG)-PUSCH should be considered: Huawei/HiSi [1], Qualcomm [27] (mux. Supported incl. A-CSI)
* Discuss if *multi-CSI-PUCCH-Resource List* should be considered: Huawei/HiSi [1], Qualcomm [27]
* Reuse the legacy UCI multiplexing/prioritization rules to determine the final PUCCH/PUSCH transmission, as well as the conveyed UCI(s) in the target slot: vivo [5]
	+ *Moderator comment: if not having any contradicting decision, R16 rules should automatically apply*
* For deferral from multiple PUCCH slots,
	+ Alt. 1: the total deferred SPS payload size is considered (of multiplex slots):
	+ Alt. 2: is individually performed for each slot and UE assumes no other deferred PUCCH exists in the determination: LGE [25]
* Qualcomm [27]: Multiplexing of deferred SPS and DG HARQ in the target slot on PUCCH resource indicated by the DCI scheduled DG HARQ. No further deferral in case of collision.
	+ *Moderator comment*: It seems we agreed this already in RAN1#106-e:
		- *For SPS HARQ-ACK deferral, the target PUCCH slot is defined as the next PUCCH slot where sps-PUCCH-AN-List-r16 or n1PUCCH-AN PUCCH resource is regarded as valid, or a 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*
			* *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.*
		- *For SPS HARQ-ACK deferral, if after the target PUCCH slot determination the deferred SPS HARQ-ACK cannot be transmitted, the deferred SPS HARQ-ACK bits are not further deferred and are dropped.*
		- *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.*
* Payload size related restrictions:
	+ China Telecom [10]: When determining the target slot/sub-slot for deferred HARQ-ACK bit(s) corresponding to a PDSCH, if the number of total deferred (with earlier PDSCH ending) and non-deferred UCI bits is larger than 2 on PUCCH format 0,1 resource, or the code rate on the PUCCH format 2,3,4 resource begins to be larger than the maximum code rate in a slot/sub-slot with valid PUCCH resource, the slot/sub-slot is not determined as target slot/sub-slot. Continue to check next slot/sub-slot with valid PUCCH resource if the maximum deferral time has not been met.
	+ Sony [19]: When the target PUCCH is overloaded, part of the deferred HARQ-ACK bits are transmitted, which are selected from the *NHARQ* deferred HARQ-ACKs corresponding to the latest SPS.
	+ Qualcomm [27]: Clarify with respect to *Modified Proposal 2.4.1*, that the maximum payload size is either (a) 1706bits or (b) the maximum payload size that can be supported from the PUCCH resource at the current slot.
		- Regarded as an error case, if the combined HARQ-ACK payload size (deferred HARQ & DG HARQ) to exceed the max. payload size

**Bit ordering of deferred SPS HARQ-ACK bits from more than one initial slot:**

* For ordering deferred SPS HARQ-ACK bits from more than one ‘initial PUCCH slot’, 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: DoCoMo [18], ETRI [20] (2nd Alt. - ‘created as a whole’)
* Each deferred HARQ sub-codebook can be appended based on the deferred number (i.e., increasing initial UL slot index): ETRI (1st Alt.), LGE [25], Qualcomm [27] (mux. of different priorities supported, regarded as HP in case of mixed priorities)

**Clarification on Flexible symbol / SFI handling:**

* Reuse Sec. 11.1 of 38.213, and consider PUCCH of deferred SPS HARQ as semi-static PUCCH: ZTE [3]

**Maximum value of k1 + k1\_def (RRC impact):**

* 15: Ericsson [2]
* >15 supported: Intel [17]

**PUCCH repetition operation:**

* No multiplexing of DG HARQ-ACK PUCCH repetition and SPS HARQ-ACK deferral in case of partial overlap, SPS HARQ-ACK is further deferred: Ericsson [2]
	+ Multiplexing only in case of full overlap (of all repetitions). In case of partial overlap, the SPS HARQ-ACK is further deferred.
* The maximum deferral value in terms of k1+k1def is the latest PUCCH starting slot, no matter with actual PUCCH repetition number (i.e., the deferral conditions are checked only for the initial PUCCH repetition): Spread rum [4], Nokia/NSB [8], CATT [9], Intel [17], ETRI [20] (?), LGE [25] (increase max deferral by the repetition factor K)
* The maximum deferral value in terms of k1+k1def is considered per PUCCH repetition occasion (i.e., if not all PUCCH repetitions are within the maximum deferral bound, the remaining PUCCH repetitions are cancelled): OPPO [6], Qualcomm [27]
* All the PUCCH repetitions of the PUCCH repetition bundle need to be within the maximum deferral value in terms of k1+k1def (otherwise, the deferred SPS HARQ-ACK is dropped): Panasonic [21]
* Simultaneous configuration of PUCCH repetition and Rel-17 SPS HARQ-ACK deferral is not supported: Samsung [15] (… as deferral of the start of the PUCCH repetition bundle based on the RAN1#106-e conclusion is implicitly already supported in R16), DoCoMo [18]
* If a PUCCH repetition could not be mapped to UL slot/sub-slot, the PUCCH repetition is not transmitted: Intel [17]
* Change the UCI dropping for SPS HARQ-ACK deferral:
	+ Intel [17]: For overlap of repeated PUCCH, when one of UCIs contains SPS HARQ-ACK with enabled deferral, the UE can expect the first PUCCH and any of the second PUCCHs to start at a same slot and include a UCI type with same priority. One of these UCIs can be dropped
	+ Panasonic [21]: The deferral periods and the number of performed PUCCH repetitions should be considered as a priority for handling the PUCCH collisions
* If PUCCH resource in a slot has repetition factor larger than 1, no HARQ-ACK deferral is triggered: LGE [25]

**Multiplexing of deferred SPS HARQ and Type 1 CB:**

* Set the related entries of deferred SPS HARQ information in Type 1 CB (if existing) to NACK: ZTE [3]

**PHY priority & SPS HARQ-ACK deferral**

* Deferring HARQ-ACK bits are supported regardless of its configured priority index: ETRI [20]
* Support multiplexing of deferred SPS HARQ-ACK bits and new DG HARQ of different priorities (assumed as HP then): Qualcomm [27]

**Further proposed restrictions:**

* UE cannot be configured with SPS HARQ-ACK deferral if configured to monitor for DCI format 2\_0 (SFI): Qualcomm [27]

**Other / misc.:**

* **HARQ process collision:**
	+ Sony [19]: When the soft-bits of an SPS PDSCH corresponding to a deferred HARQ-ACK are dropped due to HARQ Process Number collision, the UE still transmits the deferred HARQ-ACK in the target PUCCH
	+ ETRI [20]: If some deferred SPS has an overlapped HPN, then the HARQ-ACK is updated and reported
	+ *Moderator comment*: Please note, this is against the RAN1#106-e agreement of confirming the working assumption with some modifications saying we drop. Please check the RAN1#106-e chairman’s notes.
* Qualcomm [27]: 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
	1. 1st Round of email discussions

**Maximum deferral value (RRC impact)**

We did not agree yet to define the maximum deferral value which is still FFS. For the RRC parameter list it would be good to have this clarified. Ericsson suggested as maximum value 15 that can be configured (same as the maximum value of k1 that can be configured) whereas Intel suggests a larger value (>15).

Looking at the draft RRC parameter list we have there the following:

|  |  |  |
| --- | --- | --- |
| spsHARQ-ACKdeferral-max | Enable the SPS HARQ-ACK deferral and configure the maximum SPS HARQ-ACK deferral value in terms of k1+k1,def per SPS configuration.  | {1…FFS: 15} |

Clearly, a smaller value than 15 does not seem to make sense but it is also not clear if a larger value would be needed (than basically supported for DG PDSCH). So, let’s check where companies stand – if companies do not agree with proposal below (i.e., larger value than 15 should be supported), companies are encouraged to provide their input on the maximum value in the table below:

**Proposal 2.2.1: The maximum value that can be configured as the maximum SPS HARQ-ACK deferral value in terms of k1+k1def per SPS configuration is 15 (i.e., RRC value range is {1…15}).**

|  |  |
| --- | --- |
| Supporting companies  | Ericsson, Nokia/NSB, Samsung, Panasonic, CATT, ZTE, DOCOMO… |
| Companies not supporting | Intel, QC, Sony Huawei/Hisi |

Please provide your comments in below table (if you think a larger value is needed, and what is the maximum value):

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Intel | Let us first see if there are more views on changing 15 to a larger value. From our perspective, we think larger values may be well motivated by the deferral procedure enabled together with sub-slot operation, where the deferral is SPS configuration specific – different configurations may relate to different services with different delay and reliability requirements. |
| QC | This topic is of secondary priority now, always considering that other important topics are still open. With regards to the maximum deferral value, this value depends on several factors, such as SCS, traffic type, etc. Why e.g. 15 and not 7, hence deferral up to 8 slots, which is at least 1 ms (for SCS equal to 120 kHz).Proposal not motivated by the limited amount of companies (3 out of 29) having expressed their opinion on the topic. This is not an impartial discussion moderation. |
| Ericsson | Although we are OK with 15 as indicated above, we also don’t mind if companies prefer more discussion to ensure a suitable value is configured. |
| Samsung | For latency purposes, no need for a number larger than 15. Similar for data rate pursposes as the NW will run out of HARQs. There are much more effective mechanisms introduced in Rel-17 to address the issue that deferring for potentially 32+ slots.  |
| Moderator | @QC: the maximum value is 15, so the gNB can indicate any value between one and 15 (granularity is 1 slot based on RRC parameter draft). So having 15 as maximum, any value of set [1,2,…15] can be indicated |
| Sony | 15 may be limiting in higher SCS and sub-slot, notably 2 OFDM symbols sub-slot are used. |
| vivo | Although no strong view, it would be good that proponents for supporting larger values can give some detailed values so that we can make progress.  |
| LG | We are fine with the proposal for slot-level scheduling. For sub-slot case, it is discussable whether 15 sub-slot range is sufficient to avoid DL symbols in a slot. It would be good to have differnet value ranges for slot and sub-slot.  |
| Huawei/Hisi | Share a similar view as Intel. When combined with subslot length, e.g., with length of 2OS, the max deferral value is as short as ~2 slots, where the deferral would probably expire before it reaches the latest available UL slot in case the DCI locates at an early DL slot of the TDD frame with 4:1/7:3/8:2 configuration. To this end, we recommend some larger values are also added on top of the legacy range, e.g., **20 x 7OS-subslots** (10 slots), **30 x 7OS-subslots** (15 slots), **35 x 2OS**-**subslots** (5 slots), **70** **x 2OS**-**subslots** (10 slots), **105** **x 2OS**-**subslots** (15 slots). Note that to avoid too large delay for the slot case, we need a limitation that the extra added k1 values **applies only for the sub-slot case**. |
| Moderator | @Huawei & Intel: Why is there a need to defer longer, than what can be done through dynamic PDSCH scheduling? Also there, we are limited for any sub-slot operation to a maximum of 15 sub-slots? I would understand, if for DP PDSCH we would have such large k1 values, but why having larger value here now? So what is so special about SPS that we need extra long k1 value, whereas for DG PDSCH we would not need!?? |

**Additional clarifications on initial slot operation / handling:**

There had been comments from several companies, that the agreement on the initial slot handling is not fully clear (see summary section 2.1). The moderator acknowledges this, as we down-selected in the GTW session directly to Alt. 1 without further being more detailed (in contrast to the target slot definition and handling, where some sub-bullets had been added to further clarify this by email discussion).

The moderator has the following understanding of the intention when taking the decision to go with Alt. 1:

* In the initial slot, the Rel-16 HARQ-ACK multiplexing operation applies. If after performing the Rel-16 HARQ-ACK multiplexing procedure, 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, the applicable SPS HARQ-ACK is deferred.
	+ i.e., if the SPS HARQ-ACK configured for deferral is mapped to a PUCCH resource of another PUCCH configuration than SPS-PUCCH-AN-List-r16 or n1PUCCH-AN and /or PUSCH, the SPS HARQ-ACK is not deferred.
* The decision to defer some SPS HARQ-ACK in the initial does not change any UCI multiplexing in the initial slot (i.e., partial HARQ-ACK transmission is not supported)

**Modified Propos~~al~~ed Conclusion 2.2.2: For SPS HARQ-ACK deferral, the operation in the ‘initial’ slot is further clarified as:**

* **Alt. 1 (Based on Samsung, decision after R16 multiplexing on PUCCH/PUSCH): The UE performs first the (Rel-16) UCI multiplexing operation. If after the UCI multiplexing operation into a PUCCH or PUSCH, the UE would be transmitting SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN which is not valid, the SPS HARQ-ACK configured for deferral is deferred.**
* **Alt. 2 (mod. based on Ericsson, before considering overlapping PUSCH): If after determining a PUCCH resource for carring the HARQ-ACK in the initial slot, the UE would be transmitting SPS HARQ-ACK using a PUCCH resource from the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN, and the UE determines that the PUCCH resource is not valid, the SPS HARQ-ACK configured for deferral is deferred.**
* **~~The decision to defer some SPS HARQ-ACK in the initial does not change any UCI multiplexing in the initial slot (i.e., partial HARQ-ACK transmission is not supported)~~**

|  |  |
| --- | --- |
| Alt. 1 | Panasonic, ZTE, DOCOMO |
| Alt. 2 | Ericsson, Huawei/Hisi |
| Alt. 3 – other | Sony, CATT,  |

Please provide in below table your comments on the moderator understanding & the related clarifications

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Intel | For clarification, is our understanding correct that the first sub-bullet intends to say “The UE performs first the (Rel-16) UCI multiplexing operation on PUCCH” ? That means, it does not consider possible outcomes of multiplexing of UCI on PUSCH to decide on deferral – if that is correct understanding of the wording, then we are supportive. |
| QC | Can you confirm the understanding: The motivation with this proposal is to support multiplexing of SPS HARQ colliding with DL symbols with DG PUCCH and with DG/GG PUSCH? Hence, support for intra-slot multiplexing at the initial slot? If yes, the proposal is supported. |
| Ericsson | * The intention is clairficaiton. Hence, we suggest changing Proposal 2.2.2 to “Proposed conclusion 2.2.2”.
* Although the intention is clear, the proposed text is problematic using “UCI multiplexing” . since it is borad and can create more confusion. Also, last bullet is confusing.
* Some suggestion below. With changes in first bullet, it should be clear that there is only HARQ-ACK SPS in that slot, that would fit or not. With that clarification, there should be no need to second bullet (unless we misunderstood the intention).

**Proposed conclusion:****For SPS HARQ-ACK deferral, the operation in the ‘initial’ slot is further clarified as:** * **~~The UE performs first the (Rel-16) UCI multiplexing operation.~~ If after determining a PUCCH resource for carring the HARQ-ACK ~~multiplexing operation on~~ in the initial slot, the UE would be transmitting SPS HARQ-ACK using a PUCCH resource from the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN, and the UE determines that the PUCCH resource is not valid, the SPS HARQ-ACK configured for deferral is deferred.**
* **~~The decision to defer some SPS HARQ-ACK in the initial slot does not change any UCI multiplexing in the initial slot (i.e., partial HARQ-ACK transmission is not supported)~~**
 |
| Samsung | It needs to be clarified whether or not UCI on PUSCH is considered. In Rel-15/16, HARQ-ACK for SPS can be multiplexed into CG PUSCH or DG PUSCH although corresponding PUCCH for the HARQ-ACK is not transmitted due to semi-static TDD configuration. The same approach should be kept for SPS HARQ deferring. This makes UE implementation simpler since this is Rel-15/16 design. Without considering UCI on PUSCH, a UE would implement the multiplexing rule differently depending on whether HARQ-ACK for SPS is configured with deferring or not. We prefer to minimize any impact on multiplexing procedures.In addition, Rel-16 UCI multiplexing has been agreed to be supported in the target slot, there is no reason to have a different design for the intial slot. In our understanding, UCI multiplexing includes UCI multiplexing in a PUCCH and UCI multiplexing in a PUSCH. We suggest the following update**Updated Proposal 2.2.2: For SPS HARQ-ACK deferral, the operation in the ‘initial’ slot is further clarified as:** * **The UE performs first the (Rel-16) UCI multiplexing operation. If after the HARQ-ACK multiplexing, if any~~operation on PUCCH~~, the UE would be transmitting SPS HARQ-ACK using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN which is not valid, the SPS HARQ-ACK configured for deferral is deferred.**
* **The decision to defer some SPS HARQ-ACK in the initial does not change any UCI multiplexing in the initial slot (i.e., partial HARQ-ACK transmission is not supported)**
* **Note: UCI multiplexing includes UCI multiplexing in a PUCCH and UCI multiplexing in a PUSCH**
 |
| Moderator | Updated proposal with two Alternatives,  |
| Sony | We have similar comment regarding multiplexing SPS HARQ-ACK into PUSCH. If the UE could multiplex the HARQ-ACK into PUSCH, they should not be deferred. Hence we support the changes made by Samsung for the 1st bullet.On the 2nd bullet, it isn’t clear what we are trying to address. We did not agree to have partial multiplexing in initial slots, unless I have missed some agreements on this. |
| CATT | Our understanding of the intention of the previous agreement is to perform UCI multiplexing on PUCCH/PUSCH first. If SPS HARQ-ACK is multiplexed on a PUCCH/PUSCH which is valid (i.e. does not collide with semi-static DL symbols, SSB and CORESET#0), the SPS HARQ-ACK is not deferred. Otherwise if SPS HARQ-ACK is multiplexed on a PUCCH/PUSCH which is not valid, the SPS HARQ-ACK is deferred.In addition, we think the interaction between Rel-17 intra-UE multiplexing and SPS HARQ-ACK deferral needs to be considered if they can be operated simultaneously. Accordingly, our proposal based on the original proposal is as follows.**For SPS HARQ-ACK deferral, the operation in the ‘initial’ slot is further clarified as:** * **The UE performs first the ~~(Rel-16)~~ UCI multiplexing operation. If after the HARQ-ACK multiplexing operation on PUCCH and/or PUSCH, the ~~UE would be~~ PUCCH or PUSCH used for transmitting SPS HARQ-ACK ~~using the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN~~ is not valid, the SPS HARQ-ACK configured for deferral is deferred.**
	+ **FFS interaction with Rel-17 intra-UE multiplexing**
* **~~The decision to defer some SPS HARQ-ACK in the initial does not change any UCI multiplexing in the initial slot (i.e., partial HARQ-ACK transmission is not supported)~~**
 |
| vivo | We would like to clarify our understanding on following:For Alt.1 and Alt.2, after the UCI multiplexing operation on PUCCH, including multiplexing with HARQ-ACK and CSI/SR, if the final PUCCH other than the one configured in SPS-PUCCH-AN-List-r16 or n1PUCCH-AN is not valid (e.g. final PUCCH is the one configured for CSI and cancelled), then the SPS HARQ-ACK is not deferred further and dropped. Correct?For Alt.2: If a PUCCH resource from the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN is not valid, even if there is avalible DG/CG PUSCH that can multiplex with the SPS HARQ-ACK, the SPS HARQ-ACK will not multiplex on the DG/CG PUSCH, but deferred. Correct?This may have impacts for the target slot handling. In general, we prefer to have a unified solution for both initial and target slot. So, if UCI multiplexing on PUCCH including HARQ-ACK and/or CSI/SR, or HARQ-ACK multiplexing on PUSCH is used for determining when to defer from the initial slot/sub-slot, then the UCI multiplexing on PUCCH or PUSCH should also be used for determining the target slot; Alternatively, to simplify the procedure, if the UCI multiplexing on the final PUCCH resource other than the dynamic PUCCH, or HARQ-ACK multiplexing on PUSCH is not used for determining when to defer from the initial slot/sub-slot, then it should not be used for determining the target slot either.  |
| LG | We understood that the purpose of Alt. 1 was to simply UE behavior by not allowing deferral when PUCCH are involved into UL multiplexing. Meanwhile, The proposal is to specify the conditions that deferral can occur with UL multiplexing if PUCCH resource is not changed. We think that it make the problem more difficult since the PUCCH has logical and physical meaning. For example, if SPS HARQ-ACK is muxed with CSI and CSI resource are indicating same PUCCH resource ID in SPS-PUCCH-AN-List-r16, it is questionable the SPS HARQ-ACK can be deferred or not. In this point of view, we suggest to consider only whether UL multiplexing is performed or not rather than considering whether PUCCH resource is changed. We don’t see technical reason for such behavior. Between alternatives, we prefer Alt. 2 |
| ZTE | I share the similar views with Samsung to interprete the agreement of last meeting.  |
| Huawei/Hisi | Our understanding is Alt.2, as the UE will determine the target PUCCH slot based on whether thePUCCH from *sps-PUCCH-AN-List-r16*,*n1PUCCH-AN* PUCCH, or *PUCCH-ResourceSet* is regarded as valid. The decision of the target PUCCH slot occurs after the UE generates the PUCCH for HARQ-ACK (FFS whether including SR), and before the UE performs the remaining multiplexing (with CSI/CG PUSCH/DG PUSCH) as R16. If there is further conflict during the remaining multiplexing procedure (e.g., conflict with DL/SSB, or dropped due to prioritization/cancellation), the SPS HARQ-ACKs will be dropped without further deferral.Some modifications as below on top of Alt.2:**If after determining a PUCCH resource for carring the HARQ-ACK [FFS: and SR] in the initial slot, the UE would be transmitting SPS HARQ-ACK using a PUCCH resource from the PUCCH SPS-PUCCH-AN-List-r16 or n1PUCCH-AN, and if the UE determines that the PUCCH resource is not valid, the SPS HARQ-ACK configured for deferral and having not reached maximum SPS HARQ-ACK deferral value is deferred.** |
| Moderator | Thanks for the good input. On alternative 2, wouldn’t this mean that the SPS HARQ may be transmitted in the initial slot (if e.g. multiplexed with other UCI on PUCCH – e.g. CSI, or on PUSCH) and still deferred? So there would be unnecessary SPS HARQ deferral which was the reason initially to go for Alt. 1 compared to other alternatives?Maybe some of the Alt. 2 companies could clarify here@CATT: PUSCH collision with SSB & SS-DL symbols, for DG PUSCH I guess this should anyhow not happen. Not sure about CG PUSCH though. @HW: I guess there would not be the case in the initial slot, that a UE configured for deferral would have reached the maximum deferral already? I tried to have this clarified in   |
| Samsung2 | Alt 2 in the updated proposal is in essence Alt 1-A instead of the adopted Alt 1. Whether Rel-15/16 UCI multiplexing should be changed was discussed RAN1#104b. Proponents of Alt 1 don’t support it, only proponents of Alt 1-A supports changing Rel-15/16 UCI multiplexing rules. The common understanding of Alt 1 is not changing Rel-15/16 UCI multiplexing rules. Copied the analysis of FL in RAN1#104b below.* Comparing the all alternatives, they differ seem to differ in the following properties
	+ Should HARQ-ACK be deferred, even if multiplexing in the initial slot would be possible (resulting in larger HARQ latency)?
		- Yes: Alt. 1A (defer in case of collision of SPS HARQ resource even if otherwise mux is possible)
		- No: Alt. 1, 3, 3A (using Rel-16 multiplexing rules in the initial slot), Alt. 2 (intra-slot deferral to another resource if Rel-16 mux is not working out)
	+ Can the Rel-16 UCI/HARQ-ACK multiplexing rules be changed in initial slot?
		- Yes: Alt. 1A (defer in case of collision even if mux possible) , Alt. 2 (intra-slot deferral to another resource if Rel-16 mux is not working out)
		- No: Alt. 1, 3 & 3A
 |
| DOCOMO | We support Alt 1 so that Rel-15/16 UCI multiplexing behavior should not be changed. And we also think the “Rel-15/16 UCI multiplexing” includes both UCI multiplexing on PUCCH and also UCI multiplexing on PUSCH. Assuming that there are SPS HARQ-ACK bits subject to deferral and not subject to deferral, how will we treat the SPS HARQ-ACK bits not subject to deferral if we defer SPP HARQ-ACK bits subject to deferral? Will they be dropped? Or will they be multiplexed? Such handling needs much further discussion and it is not preferred. |

**Additional clarifications on initial slot operation / handling:**

There had been comments from several companies, that the agreement on the target slot handling may not fully clear (see summary section 2.1).

The moderator would hereby like to again copy the related available proposals here:

|  |
| --- |
| **Agreement**For SPS HARQ-ACK deferral, only SPS HARQ bits subject to deferral from HARQ-ACK codebook from an initial PUCCH slot are deferred to the target PUCCH slot**Agreement** 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 **Agreement**For SPS HARQ-ACK deferral, the target PUCCH slot is defined as the next PUCCH slot where *sps-PUCCH-AN-List-r16* or*n1PUCCH-AN* PUCCH resource is regarded as valid*,*or a 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
* 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.

**Agreement**For SPS HARQ-ACK deferral, if after the target PUCCH slot determination the deferred SPS HARQ-ACK cannot be transmitted, the deferred SPS HARQ-ACK bits are not further deferred and are dropped.**Agreement**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. |

The comments there include what happens with overlapping DG/CG-PUSCH, *multi-CSI-PUCCH-ResourceList* or if there is a scheduled PUCCH by a DG PDSCH.

The moderator would thereby like to note the following (based on his understanding):

* Based on the agreements above the moderator has the following understanding:
	+ The total deferred SPS HARQ-ACK payload size (from one or more initial slots) is considered when deciding if a PUCCH is a target slot or not
		- Splitting HARQ-ACK bits per initial slot is not supported (i.e., the total amount of pending SPS deferred HARQ-ACK bits are ‘jointly’ considered for deferral)  reply to LGE, Sony
	+ The current agreement basically is not considering *multi-CSI-PUCCH-ResourceList*, i.e., the presence of P/SP-CSI in the PUCCH slot is not considered in the determination of the target slot  reply to HW/HiSi & QC
	+ The target slot determination does not consider the presence of (CG/DG-) PUSCH, as the target slot determination is based on PUCCH only (and multiplexing decision on PUSCH is done only afterwards)  reply to HW/HiSi (& QC?)
	+ After the target slot has been determined, the Rel-16 UCI multiplexing is applied (as we don’t have any other conflicting agreement). This includes the potential multiplexing of the deferred SPS HARQ-ACK on *multi-CSI-PUCCH-ResourceList* and/or PUSCH  reply to HW/HiSi, QC

**Question 2.2.3: Based on the points above, do you think that (except the maximum payload size handling, see below) any further clarifications to the target slot determination and handling in the target slot would be still needed?**

|  |  |
| --- | --- |
| Yes – further clarifications needed | QC – multiplexing with CSI, PUSCHSamsung, Sony, CATT, Huawei/Hisi, DOCOMO |
| No further clarifications needed | Nokia/NSB, Panasonic,… |

Please provide further input below

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Intel | We agree with Moderator’s points and would like to avoid “optimizing” the operation further by considering multiplexing on CG/DG PUSCH or CSI resource. If the agreements are not clear, prefer excluding those cases explicitly. |
| QC | A high level note: multiplexing of deferred SPS HARQ with CSI and PUSCH is not an ‘optimizaiton’. It is the Rel. 16 behavior serving the goal of the SPS HARQ deferral feature.Some notes:* + “The total deferred SPS HARQ-ACK payload size (from one or more initial slots) is considered when deciding if a PUCCH is a target slot or not
		- Splitting HARQ-ACK bits per initial slot is not supported (i.e., the total amount of pending SPS deferred HARQ-ACK bits are ‘jointly’ considered for deferral)  reply to LGE, Sony
* QC: This reasoning is against the agreement

AgreementFor SPS HARQ-ACK deferral, only SPS HARQ bits subject to deferral from HARQ-ACK codebook from an initial PUCCH slot are deferred to the target PUCCH slot* + The current agreement basically is not considering *multi-CSI-PUCCH-ResourceList*, i.e., the presence of P/SP-CSI in the PUCCH slot is not considered in the determination of the target slot  reply to HW/HiSi & QC

QC: Agreement with “The current agreement basically is not considering *multi-CSI-PUCCH-ResourceList*”. Therefore, it is needed to modify the proposal so as to consider *multi-CSI-PUCCH-ResourceList* as well. The goal of the whole feature is to reduce latency. Moreover, the SPS HARQ deferral feature, with its current shape, is very far from being useful, since it requires very advanced scheduling and uplink resource reservation so as collisions are avoided. If there is another scheduled PUCCH resource available, it has to be used.* + The target slot determination does not consider the presence of (CG/DG-) PUSCH, as the target slot determination is based on PUCCH only (and multiplexing decision on PUSCH is done only afterwards)  reply to HW/HiSi (& QC?)

QC: Same argument as above. Multiplexing with existing already granted uplink resources should be considered first and then decision whether the current slot is indeed a target slot. Not using an uplink resource is against the goal of this feature, which is to reduce latency and result in higher resources efficiency.” |
| Ericsson | In some sense this is like “Alt2” earlier where new resources are added for SPS HARQ-ACK transmission. But it also extends to multiplexing, i.e., allowing multiplexing of SPS HARQ-ACK in invalid PUCCH with other UCI or PUSCH in a slot to avoid deferring. This seems complicated as it changes the multiplexing procedure. It may be better to separate SPS HARQ-ACK deferral to just “determining a new K1 for PUCCH” and then applies the existing procedure like multiplexing afterwards. |
| Samsung | Similar to initial slot, at least considering multiplexing on CG/DG PUSCH is necessary since this is Rel-15/16 behavior and can also provide shorter latency. We have the following agreementsAgreements: Rel-16 UCI multiplexing / PUCCH overriding rules are reused for deferred SPS HARQ-ACK in the target slot, if applicable.As we clarified for Proposal 2.2.2, UCI multiplexing includes UCI multiplexing in a PUCCH and UCI multiplexing in a PUSCH. We don’t agree with FL on “The current agreement basically is not considering *multi-CSI-PUCCH-ResourceList*, i.e., the presence of P/SP-CSI in the PUCCH slot is not considered in the determination of the target slot”, in our understanding, if SPS HARQ-ACK is multiplexed in a CSI PUCCH in slot n, the slot n is the target slot. No further deferring regardless whether the CSI PUCCH is valid or not. We don’t agree with FL on “multiplexing decision on PUSCH is done only afterwards”, we think multiplexing is done before checking SPS HARQ-ACK deferral. Note, in the first bullet of Proposal 2.2.2, “The UE performs first the (Rel-16) UCI multiplexing operation.”, why we should have different design for intial slot and target slot? |
| Sony | On the following reasoning:* The total deferred SPS HARQ-ACK payload size (from one or more initial slots) is considered when deciding if a PUCCH is a target slot or not
	+ Splitting HARQ-ACK bits per initial slot is not supported (i.e., the total amount of pending SPS deferred HARQ-ACK bits are ‘jointly’ considered for deferral)  reply to LGE, Sony

The agreement said that:***Agreement*** *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* Each PUCCH carrying SPS HARQ-ACK that is dropped can be considered for deferral to a target PUCCH slot. Hence, we can drop some of these initial PUCCHs to make room for other (later) PUCCHs in the target PUCCH slot. Also this reasoning seems to contradict the Proposal 2.2.5 below, where the jointed HARQ-ACK can be broken apart so that those that exceeded k1+k1def can be discarded whilst those still within the k1+k1def can continue on to find a target PUCCH.On this reasoning:* The target slot determination does not consider the presence of (CG/DG-) PUSCH, as the target slot determination is based on PUCCH only (and multiplexing decision on PUSCH is done only afterwards)

We think that if in the initial slot the SPS HARQ-ACK can be multiplexed into PUSCH then there should not be any deferral. As QC & Samsung said if we now decide to defer SPS HARQ-ACK without considering multiplexing into PUSCH, we are breaking Rel-15 & Rel-16 behaviour. On the target slot, what are the steps, that is:1. If we consider SPS HARQ-ACK deferral into target PUCCH first then consider target PUCCH multiplexing into PUSCH, then then the deferred HARQ-ACKs are multiplexed into PUSCH
2. If we consider target PUCCH mux into PUSCH first then only SPS HARQ-ACK, then this means we do not defer the HARQ-ACKs?
 |
| CATT | Our understanding of the previous agreement is to adopt the same rule for target slot determination as for initial slot. Therefore, it is our understanding that UCI multiplexing is performed before determining target slot. Therefore, different from moderator’s understanding that PUSCH and *multi-CSI-PUCCH-ResourceList* are not considered for target slot determination, we think they are considered. In addition, it is not clear whether the initial SPS HARQ-ACK, dynamic PUCCH and SR are considered or not from the moderator’s understanding. |
| vivo | Similar comments as for Proposal 2.2.2. In general, we prefer to have a unified solution for both initial and target slot. So, if UCI multiplexing on PUCCH including HARQ-ACK and/or CSI/SR, or HARQ-ACK multiplexing on PUSCH is used for determining when to defer from the initial slot/sub-slot, then the UCI multiplexing on PUCCH or PUSCH should also be used for determining the target slot; Alternatively, to simplify the procedure, if the UCI multiplexing on the final PUCCH resource other than the dynamic PUCCH, or HARQ-ACK multiplexing on PUSCH is not used for determining when to defer from the initial slot/sub-slot, then it should not be used for determining the target slot either.  |
| LG | First of all, At least it should be clarified what determine valid target PUCCH. From first to third moderator’s understanding, it seems that target slot is determined by valid “HARQ-ACK” PUCCH before multiplexing. However, it is different from the way to determined valid PUCCH in initial slot. Since we think the agreement for target slot is to have same principle of initial PUCCH, we prefer to align those two. And for the case of deferred SPS HARQ bits from more than one ‘initial PUCCH slot’, we can consider total pending HARQ-ACK bits or perform deferral per intial slot indivisually as if there is no other deferral occurance. In order to take former, we think it should be clarified how to determine maximum deferral for that case, otherwise, HARQ-ACK would be splitting eventually. In order to avoid optimization, we suggest to perfrom deferral per initial slot and target slot is determined by initial HARQ-ACK and single deferred HARQ-ACK with specifying error case.  |
| Huawei/Hisi | Similar with 2.2.2. We try to provide the full procedure for SPS deferral at the initial slot/candidate target slot based on our understanding to the agreement:**Step1**: UE performs the R16 HARQ-ACK multiplexing (including the initial SPS HARQ-ACK if any, deferred SPS HARQ-ACK if any, DG HARQ-ACK if any), and determines the PUCCH for HARQ-ACK.**Step2**: Determine the target slot based on the determined PUCCH. If the determined PUCCH is from *SPS-PUCCH-AN-List-r16* or *n1PUCCH-AN* and is not valid, defer the SPS HARQ-ACKs which are configured with SPS deferral and having not reach max deferral value to the next slot; otherwise the the target slot is the current initial slot/candidate target slot, and go to Step3.**Step3**: Continue R16 UCI multiplexing, including the potential multiplexing with CSI, and CG/DG PUSCH. If any channel carrying the SPS HARQ-ACK during the multiplexing procedure is dropped afterwards, the SPS HARQ-ACK is not further deferred.But one more question for **the multiplexing with SR**: whether the multiplexing with SR happens in Step 1, or Step 3? Our understanding is that as the multiplexed SR and SPS HARQ-ACK is also carried on PUCCH from *SPS-PUCCH-AN-List-r16* or *n1PUCCH-AN*, it should be in Step1. |
| DOCOMO | We share same understanding on current agreements as the moderator. But we THINK that the CSI/PUSCH multiplexing should be clarified for target slot determination. As we select Alt 1 in Proposal 2.2.2, multiplexing with CSI or PUSCH is performed before deferring determination. In our understanding, behavior in initial slot and in later deferred slot should be aligned. We think such UCI multiplexing should also be before deferral determination in later slots, i.e. before target slot determination. If different handling for initial slot and non-initial slot, one possible issue that one slot includes both initial SPS HARQ-ACK bits and non-initial HARQ-ACK bits may occur as in the following example. |

On the **maximum payload size**, there had been last meeting a strong majority (all except one company) thinking that there is no need to define some payload specific handling and exceeding the maximum payload size should be regarded as an error case. Qualcomm thought some clarification would be needed if this is either (a) 1706bits or (b) the maximum payload size that can be supported from the PUCCH resource at the current slot. Let’s see if this could be agreeable this time with the further clarification that this is the payload size of the PUCCH configurations in the target slot.

**Propos~~edal~~ Conclusion 2.2.4: For HARQ-ACK deferral, the UE does not expect the total UCI payload size in the target PUCCH slot to exceed**

* **Alt. 1: the maximum payload of the PUCCH configuration(s) of the target slot.**
* **Alt. 2: 1706 bits**

|  |  |
| --- | --- |
| Alt. 1 | Panasonic, CATT, vivo,TCL Huawei/Hisi, DOCOMO |
| Alt. 2 | ZTE |
| Alt. 3 – other | Sony (behaviour of UE needs clarification) |

|  |  |
| --- | --- |
| ~~Supporting companies~~ | ~~Nokia/NSB, Intel, Samsung …~~ |
| ~~Objecting companies~~ | ~~QC, Ericsson (please see comment)~~ |

Further comments:

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Nokia/NSB | Having the limit set to 1706 bits may not be sufficient, as the PUCCH resource may not be able to carry the UCI although being below 1706bits  |
| Qualcomm | With this proposal, what is meant is that deferral might stop at a given slot k – well before the maximum deferral, if the total UCI payload that can be supported at this slot k is e.g. 12 bits and the total deferred payload is 13 bits. However, at the next slot, k+1, some more flexible symbols can be used as uplink symbols and the total offered UCI payload can be 24 bits. Why deferral should stop at slot k, whilst the UE can have the option to transmit deferred SPS HARQ at slot k+1. Again, this is a strategy going against the goal of SPS HARQ deferral (which is to reduce latency).Useful to imagine scenarios with slot formats consisted of a mix of DL, UL and flexible symbols at the same slot. |
| Ericsson | We agree maximum payload size is 1706 bits.We think it is better to clarify this as a conclusion (althoguht it should be clear), than have a proposal for an agreement that would create more confusion. The intention is clear but the proposal is not accurate technically:* In PUCCH configuration for HARQ-ACK, PUCCH resources (or set of PUCCH resources) are configured for a payload size range with upper value is not configured (but specified in spec as 1706).
* PUCCH configurations are applicable to any slot. There is no “PUCCH configurations of the target slot”.

Hence, if needed (although we think it should be clear), a conclusion as below could help:* Maximum UCI size to be carried in a PUCCH is 1706.
 |
| Samsung | This should be conclusion, not agreement. It would be a NW error, the UE cannot handle it, and does not need agreement/specification as the UE behaviour would be undefined. |
| Moderator | Updated to have both options there (two Alt.), let’s see where companies stand |
| Sony | The payload size is to select the PUCCH format and if that format cannot be supported due to lack of resources, what is the behaviour? Is this supposed to be an error case or simply the target PUCCH is not valid and the UE is further deferred until *k1+k1def* is reached? |
| vivo | Replyto Sony’s question, my understanding is it is an error case.  |
| LG | We share Sony’s view and see chicken and egg problem in here. By agreements, target slot is determined by the total payload size of deferred HARQ-ACK bits and initial HARQ-ACk. To determine valid target PUCCH, the PUCCH resource for total payload size is necessary anyway. Thus, the proprosal is basically means that all of UL slot should have PUCCH which can afford sufficient payload for both deferred HARQ-ACK and initial UCI bits. We slightly prefer to consider maximum payload of PUCCH resource in candidate slot for determining target PUCCH.  |
| Huawei/Hisi | The gNB will carefully reserve the resources which are large enough to hold all HARQ-ACKs. |
| China Telecom | Since PUCCH resource is configured by RRC semi-statically, this proposal requires gNB to configure in each UL slot large enough PUCCH resource to accommodate the multiple deferred SPS HARQ-ACK in one slot. It may cause unbalanced HARQ-ACK load in UL slots and much unused PUCCH resources from our understanding. Our first preference is not depending on gNB to configure large enough PUCCH resource.If most companies’ view is supporting this proposal (Alt1 or Alt2), we can also compromise as it is simple and can avoid discussion on further solution such dropping, partrial transmission…For another thing, do we also need to consider the maxCodeRate configured in the PUCCH configuration, i.e. the UE does not expect the code rate in the target PUCCH slot to exceed the configured max code rate? |

**Bits to be deferred and ordering of deferred SPS HARQ-ACK bits in the target slot**

Some companies still discussing which bits should be subject to deferral. The moderator thought that this should be clear already, i.e., only SPS HARQ-ACK subject to deferral and have not reached the maximum deferral value are deferred to the next available PUCCH (other SPS HARQ-ACK is dropped). And the total amount of applicable deferred SPS HARQ-ACK (from one or more initial slots) are jointly deferred. Although the moderator thinks this should be clear already, just to be sure, maybe we could try to agree some related clarification.

**Mod Proposal Conclusion 2.2.5: For SPS HARQ-ACK deferral, only SPS HARQ-ACK bits subject to deferral from one or more initial slots which have not reached the maximum deferral value are jointly deferred to the next available PUCCH (other SPS HARQ-ACK ~~and/or DG PDSCH HARQ~~ is dropped).**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, QC, Panasonic, Sony, ZTE Huawei/Hisi, DOCOMO, China Telecom |
| Objecting companies | LG |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Intel | In this formulation we don’t think there is delta comparing to the agreements we already have. We are open to hear more views from other companies. |
| QC | Agreement with Intel, based on the agreements below, the network whenever schedules DG PDSCH HARQ allocates sufficient UL resources for everything. Otherwise, everything is dropped since it is an error case.**Agreement**For SPS HARQ-ACK deferral, only SPS HARQ bits subject to deferral from HARQ-ACK codebook from an initial PUCCH slot are deferred to the target PUCCH slot**Agreement** 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 **Agreement**For SPS HARQ-ACK deferral, the target PUCCH slot is defined as the next PUCCH slot where *sps-PUCCH-AN-List-r16* or*n1PUCCH-AN* PUCCH resource is regarded as valid*,*or a 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
* 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.

Modification**For SPS HARQ-ACK deferral, only SPS HARQ-ACK bits subject to deferral from one or more initial slots which have not reached the maximum deferral value are jointly deferred to the next available PUCCH (other SPS HARQ-ACK ~~and/or DG PDSCH HARQ is dropped~~). If DG PDSCH HARQ present at initial slot, and the whole combined UCI cannot be transmitted, everything, i.e. DG PDSCH HARQ and deferred SPS HARQ is treates as an error case.** |
| Ericsson | Our understanding on previous agreement is the same as descption in Proposal 2.2.5.Therefore, we share the same view as Intel. Perhaps, if needed, can be as “Proposed conclusion”, to clarify previous agreement. Otheriwse, it would create confusion wondering what the delta is, |
| Samsung | We think that current agreement is sufficient. If a majority of companies thinking the proposal is needed, it is OK to have it as a conclusion.  |
| Moderator | Updated based on good comment by Qualcomm: If DG PDSCH is present in the initial slot, there is actually no deferral (as the PUCCH resource would not be from SPS / n1AN list) |
| Sony | We agree with this proposal but just note that this seems to be against the reasoning given in Question 2.2.3 (see our comment there).  |
| CATT | We share the same view as Intel, Ericsson and Samsung that the previous agreement is sufficient. |
| vivo | We share Intel’s views. |
| LG | As mentioned in Q 2.2.3, we have a concern on handling deferred SPS HARQ-ACK from two or more initial slot at once. In addition, maximum deferral value is configured per SPS configuration rather than HARQ-ACK codebook. It should be clarified first how to defermine maximum deferral value for a codebook of multiple SPS configuration.  |
| Moderator | @LG: There is no ‘codebook of multiple SPS configurations’ after the initial slot anymore, but just SPS HARQ processes with deferral. The point being that we defer SPS HARQ information basically per HARQ processes (and not codebook) and create for each potential target PUCCH slot a new CB there (incl. the HARQ processes still applicable for deferral, i.e. have not exceeded the maximum deferral value yet). Please note, that within one initial slot, there could be HARQ of SPS configurations having different deferral values defined, already from that perspective, there cannot be the notion of a ‘codebook’ there!? |

One remaining question is how to define the bit order to SPS HARQ-ACK bits for deferral from one or more initial slots. Please note, that we cannot really talk about appending HARQ-ACK CBs from different initial slots, as the HARQ-ACK codebook in the initial slot may contain may also contain SPS HARQ-ACK not subject for deferral (e.g., of SPS HARQ processes not configured for deferral).

Looking at companies’ opinions, the following alternatives can be considered:

**Question 2.2.6: For SPS HARQ-ACK deferral, the bit ordering of deferred SPS HARQ-ACK information from one or more initial slots in the target PUCCH slot is based on:**

* **Alt. 1: Rel.16 SPS HARQ-ACK bit order principle as in clause 9.1.2 of TS38.213 is applied, i.e., based on serving cell index, SPS configuration index, SPS PDSCH slot index**
* **Alt. 2: the deferred ‘HARQ-ACK sub-codebooks’ (only containing SPS HARQ subject to deferral) are appended based on the deferred number (i.e., increasing initial UL slot index)**
* **Alt. 3: Other**

|  |  |
| --- | --- |
| Alt. 1 | DoCoMo, Nokia/NSB, Intel, Samsung, CATT, vivo, ZTE Huawei/Hisi, China Telecom… |
| Alt. 2 | ETRI, Qualcomm, Panasonic, Sony,TCL, LG … |
| Alt. 3 – other |  |

Further comments:

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Intel | Alt.1 is our underlining assumption in this feature. |
| Ericsson | We support Alt1, i.e., reusing the existing ordering. Alt.2 has spec impact and there does not seem to be extra benefit. |
| Sony | Alt 2 is a neater way, but we do not have strong preference. |
| Huawei/Hisi | Reusing R16 rule is preferred; otherwise there will be a mix of two ordering rules, e.g., for the initial SPS HARQ-ACK, it follows R16 ordering rule, while for the deferred SPS HARQ-ACKs, it follows a new rule. |
|  |  |

**PHY priority handling for SPS HARQ-ACK deferral**

Qualcomm raises a good question, namely what happens if there would be e.g., SPS HARQ-ACK of different priorities pending for deferral (e.g., from different slots). Qualcomm proposes to also for this case use a joint handling (i.e., joint deferral) here and to consider the SPS HARQ as HP, if at least one of the SPS HARQ-ACK bits for deferral is associated with HP / 2nd PUCCH config. Another alternative would be, to not consider them jointly and check the availability first for HP SPS HARQ. Anyhow, two additional alternatives sketched here, please provide your input.

**Updated Question 2.2.7: For PHY priority handling of SPS HARQ-ACK deferral, the following is applied when having pending mixed PHY priority SPS HARQ-ACK information for deferral:**

* **Alt. 1: SPS HARQ for deferral of different PHY priorities is jointly deferred to a target PUCCH slot and the total SPS HARQ-ACK payload size subject to deferral is considered as high PHY priority.**
	+ - ***i.e., multiplex LP and HP SPS HARQ-ACK for deferral and consider all the HARQ-ACK information as being high priority (i.e., associated with the 2nd PUCCH config).***
* **Alt. 2: SPS HARQ for deferral of different PHY priorities is separately deferred to a target PUCCH ~~prioritizing the deferral of high priority SPS HARQ-ACK~~**
	+ - **~~For each potential target PUCCH target slot, the UE first determines if this is a target slot for the high priority SPS HARQ and only if the slot is not applicable, checks if this would be applicable for the low-priority SPS HARQ.~~**
* **Alt. 3: If SPS HARQ of high priority is subject to deferral, any pending SPS HARQ of low priority subject to deferral is dropped.**
* **Alt. 4: Other**

|  |  |
| --- | --- |
| Alt. 1 | Qualcomm, … |
| Alt. 2 | Nokia/NSB (based on question update), Panasonic,TCL Huawei/Hisi (Samsung version), Alt 2 (based on the updated version) |
| Alt. 3  | ~~Nokia/NSB~~ |
| Alt. 4 - Other | Ericsson, ZTE,  |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Nokia/NSB | The SPS HARQ is then still multiplexed with DG PDSCH HARQ and jointly considered in a LP or HP codebook. Therefore, Alt. 1 is not really working well in this respect. Alt. 2 could be an option, but complicates the specification and UE implementation. As min. specs effort was one of the targets we think Alt. 3 should be chosen.  |
| Intel | Probably better to leave it as an open issue till the next meeting and see potential issues with such operation. At this point we don’t really like any of the alternatives, each brings additional complication/considerations, while we expect to strive to reuse existing procedures as much as possible. |
| QC | Clarification on Alt 1: if the deferres SPS HARQ CB is of high priority, then DG PUSCH won’t be LP PUCCH. The scheduler when allocating resource is aware of HP deffered HARQ CB is about to be multiplexed with what is currently scheduled. Why would the scheduler do this?Alt 3 is against the motivation of SPS HARQ Deferral.With regards to Alt 3, there is consistently inconsistence in the questions proposals. Alt 3 is against the text above question 2.2.3 “Splitting HARQ-ACK bits per initial slot is not supported (i.e., the total amount of pending SPS deferred HARQ-ACK bits are ‘jointly’ considered for deferral)” |
| Ericsson | The multiplexing procedure should follow the intra-UE multiplexing of different priorities which can be applied on top of deferral. No special handling when two features are considered jointly. 🡪 Alt.4  |
| Samsung | Alt. 2 can be well aligned with Rel-16 operation since a UE first checks multiplexing between channels having same priority - similar approach can apply for deferring. That is, 1) UE performs HARQ-ACK deferring with same priority, 2) in the target slot, if there is overlapping between HP and LP channels, following Rel-16, UE drops LP channel. Otherwise, UE transmits both channels. We suggest the following update for Alt 2.* **Updated Alt. 2: SPS HARQ for deferral of different PHY priorities is separately deferred to a target PUCCH ~~prioritizing the deferral of high priority SPS HARQ-ACK~~**
	+ - **~~For each potential target PUCCH target slot, the UE first determines if this is a target slot for the high priority SPS HARQ and only if the slot is not applicable, checks if this would be applicable for the low-priority SPS HARQ.~~**
 |
| Moderator update | Update to Alt. 2 based on Samsung input.  |
| Panasonic | Alt. 2 can meet the low latency requirements for HP. In addition, the transmission of HP HARQ-ACK as early as possible reduces the accumulated deferred HARQ-ACK information, which eventually reduces the chance of dropping. |
| Sony | What is Alt. 2 behaviour? Does the UE find separate target PUCCH for LP and HP HARQ-ACKs? If yes, how is this target PUCCH determined? Doe we now consider the L1 priority of the target PUCCH? |
| vivo | We slightly prefer Alt.2 for now. But we prefer to postone the discussion on this issue.  |
| TCL | We prefer to handle the SPS HARQ-ACK deferral for different priorities separately. |
| LG | For PUCCH resource determination, SPS HARQ-ACK of different priorities have different PUCCH resource sets so Alt. 2 is more natual way. Also, We share Intel’s view to have time to clarify the deferral procedure.  |
| ZTE | Share the similar view with Ericsson. The behaviour depends on whether the inter-priority intra-UE multiplexing is configured and actived. So Alt.4 is proposed as two different paths, one path is in case of inter-priority intra-UE multiplexing is enabled, then the behaviour is like Alt.1, the other path, inter-priority intra-UE multiplexing is NOT enabled, then Alt.2 is adopted.  |
| Huawei/Hisi | **Alt. 2: SPS HARQ for deferral of different PHY priorities is separately deferred to a target PUCCH**Some more detailed inputs as below:* If the candidate target slot is invalid for the PUCCH resource of *sps-PUCCH-AN-List-r16* or*n1PUCCH-AN*  for HP, defer the HP SPS HARQ-ACKs to the next slot; if the candidate target slot is invalid for the PUCCH resource of *sps-PUCCH-AN-List-r16* or*n1PUCCH-AN*  for LP, defer the LP SPS HARQ-ACKs to the next slot.
* If the the candidate target slot is determined as the target slot for both HP and LP, then perform the R16 prioritization procedure or the R17 multiplexing procedure as discussed in 8.3.3.

For R17 multiplexing, the UE does not expect the resulting PUCCH resource after HP&LP multiplexing is invalid for the target slot. |
| DOCOMO | We don’t support joint deferral of HP and LP SPS HARQ-ACK. UE behavior would be very complicated, especially considering different slot/sub-slot time unit for HP and LP HARQ-ACK CB. We support deferral of HP and LP SPS HARQ-ACK should be separately considered, which is the updated Alt 2. In our understanding, they are two independent issues, just like HP and LP HARQ-ACK CB can be independently generated and independently determine PUCCH resource for the two HARQ-ACK CBs in one slot. In our understanding, K1 for HP and LP HARQ-ACK can be independently increased based on corresponding slot or sub-slot time unit. Independet target slot determination for HP and LP HARQ-ACKs. Inter-priority handling is considered in the target slot, i.e. prioritization or multiplexing (Rel-17 multiplexing between LP and HP HARQ-ACK).  |

**PUCCH repetition operation:**

There has been good input on the PUCCH repetition operation. Samsung & DoCoMo brought up that basically deferral of SPS HARQ of the first PUCCH repetition is implicitly supported already, based on the following RAN1#106-e conclusion for Rel-16 operation:

|  |
| --- |
| **Conclusion (RAN1#106-e)****It is clarified that a PUCCH repetition in case b (including the first PUCCH repetition) is postponed to the next available slot if the PUCCH repetition collides with SSB symbols or symbols indicated as DL by tdd-UL-DL-ConfigurationCommon or tdd-UL-DL-ConfigurationDedicated.****There is no consensus in RAN1 for whether or not the above case is supported in Rel-15 for the first PUCCH repetition when the PUCCH is triggered by DCI.** |

Therefore, there may not be actually a need to consider PUCCH repetition handling for SPS HARQ-ACK deferral and we don’t need to discuss the related handling.

**So, let’s first check if companies agree with the assessment of Samsung & DoCoMo here. Please before giving your input check the related discussions by Samsung [15] and DoCoMo [18] before just repeating your proposal in your TDoc! In addition to the proposal by Samsung, one other alternative is suggested for consideration, namely, to not defer if the initial transmission is subject to repetition.**

**Question 2.2.8: For joint operation of SPS HARQ deferral and PUCCH repetition, the following is adopted:**

* **Alt. 1: Simultaneous configuration of PUCCH repetition and Rel-17 SPS HARQ-ACK deferral is not supported.**
	+ **i.e., the UE is not expected to be configured with *nrofSlots* for any applicable PUCCH format and not expected to be configured with repetition for any PUCCH resource for the Rel-17 dynamic PUCCH repetition indication operation.**
	+ ***Note: no further handling or clarification for the PUCCH repetition operation would be needed***
* **Alt. 2: If the PUCCH format or PUCCH resource in the initial slot has a PUCCH repetition factor larger than 1, no HARQ-ACK deferral is triggered.**
	+ ***Note: Parallel deferral procedures are prevented. Depending on the PUCCH format and / or PUCCH resource and its associated PUCCH repetition factor in the initial slot, deferral is prevented (for K>1).***
	+ ***Note: this requires further clarification for the PUCCH repetition operation of SPS HARQ deferral starting from the target PUCCH slot***
* **Alt. 3: Support also SPS HARQ-ACK deferral for the case of PUCCH repetition in the initial slot.**
	+ ***Note: there would be two competing deferral procedures operating at the same time: The one from PUCCH repetition operation and the one from SPS HARQ-ACK deferral – so additional clarifications and handling would be needed (on top of Alt. 2)***
* **Alt. 4: Other:**

|  |  |
| --- | --- |
| Alt. 1 | Nokia/NSB (2nd preference), Samsung, ZTE Huawei/Hisi, DOCOMO (2nd preference) |
| Alt. 2 | Nokia/NSB (1st preference), Intel, Panasonic(2nd preference), Sony, CATT, vivo, DOCOMO (1st preference) |
| Alt. 3  | Panasonic (1st preference) |
| Alt. 4 - Other | Joint configuration of Rel. 16 repetitions and Rel. 17 SPS HARQ deferral is possible. Multiplexing of DG PUCCH configured with repetitions and SPS HARQ deferral configured with repetitions is not allowed according to Rel. 16 Intra-UE multiplexing rules. If SPS HARQ is configured with repetitions and SPS HARQ deferral is activated, repetitions are transmitted according to Rel. 16 procedure up to the maximum deferral time. |

Further comments:

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Nokia/NSB | Alt. 3 complicates the specification without any benefit – so Alt. 1 or Alt. 2 should be chosen. Alt. 2 has a slightly higher specs impact, but we think this would be the best technical solution here compared to Alt. 1.  |
| Intel | Taking into account the clarification made in RAN1#106-e, we support Alt.2 |
| QC | Alt 4. The argument that 2 different competing deferral procedures will be activated is not valid. |
| Ericsson | * We don’t support Alt-1.
* We think Alt-2 and Alt-3 descriptions needs more clarification. We are not sure even if our proposal is captured (Alt- 3?). We explain our view as the following:

Our understanding is that PUCCH repetition has a built-in deferral support so there is no need to define additional deferral behavior. (Not sure why there should be a restriction on configurtions (e.g., Alt1) though.)It could be that SPS HARQ-ACK with repetition happens to collide with another PUCCH repetition carrying HARQ-ACK. Then allow SPS HARQ-ACK with repetition to defer further if it paritally collides with another PUCCH repetition with HARQ-ACK. If it was intended as Alt-3, we suggest following modification, or to be considered as Alt-4,* **Alt. 3: Support also SPS HARQ-ACK deferral for the case of PUCCH repetition ~~initial~~ slot as the following.**
* **PUCCH with SPS only HARQ-ACK colliding with PUCCH repetiton with UCI of different priority or Type (i.e. CSI, SR).**
	+ **Dropping is applied following Rel-15/Rel16**
* **PUCCH with SPS only HARQ-ACK colliding with a PUCCH repetiton with HARQ-ACK of the same priority**
	+ **If in initial slot, PUCCH for SPS only HARQ-ACK collides with Nth repetiton of the PUCCH with HARQ-ACK**
		- **If N=1 (full overlap), follow exiting rules to multiplex HARQ-ACK**
		- **If N>1 (partial overlap), further defer SPS HARQ-ACK**
 |
| Samsung | Alt. 3 is not needed since both features provide same behaviour. For semi-static PUCCH repetition, Alt. 1 should be considered and that is sufficient for SPS PDSCH and HARQ-ACK deferral; otherwise, if repetitions are to be supported, since later HARQ-ACK cannot be multiplexed, the specifications will become more complex and any benefit would be questionable.  |
| Moderator | @Qualcomm: there is the autonomous PUCCH repetition deferral based on the RAN1 agreement in the last meeting on the R15/R16 PUCCH repetition operation. The question then would basically be what is the initial slot for PUCCH repetition, as if the first repetition is colliding, the first repetition is ‘deferred’ already. This is the point that Qualcomm is pointing out. @Ericsson: we only need to discuss the deferral operation – if we decide that deferral in that case is supported. Let’s discuss the operation then, if we know first, if there is support for that case in Rel-17.  |
| Panasonic | Alt. 3 could ensure the reliability requirements with some specification efforts. Alt. 2 has lower specification impact. |
| CATT | We support Alt. 2 with the understanding that the PUCCH format or PUCCH resource refer to the PUCCH used for SPS HARQ-ACK transmission after UCI multiplexing if any.In addition, we think the same rule should be adopted for target slot determination. Besides, further discussion is needed for the case when some of the SPS HARQ-ACK exceed the maximum deferral time limitation. |
| vivo | We share Intel’s views.  |
| ZTE | We have a conclusion that :**Conclusion****It is clarified that a PUCCH repetition in case b (including the first PUCCH repetition) is postponed to the next available slot if the PUCCH repetition collides with SSB symbols or symbols indicated as DL by**tdd-UL-DL-ConfigurationCommon**or**tdd-UL-DL-ConfigurationDedicated**.*** **There is no consensus in RAN1 for whether or not the above case is supported in Rel-15 for the first PUCCH repetition when the PUCCH is triggered by DCI.**

It seems the PUCCH repetitions will autonomously defer, why we need simutanelously configured the two functions together? |
| Huawei/Hisi | If the PUCCH repetition is configured, it naturally supports PUCCH postpone in case of collision with DL/SSB as per the agreement for R16 PUCCH repetition. So there is no need to configure both at the same time. |
| DOCOMO | We think Alt 2 can provide the possibity to apply SPS HARQ-ACK deferral to PUCCH with repetition number as 1. It is our first preference. Alt 1 is the simplest from specification perspective. Alt 3 is not preferred considering specification effort. |

# 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

 **Agreement** Confirm the following RAN1#105-e 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 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, …).

**Agreement** 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.

**Agreement** 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. **Agreement** 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.

**Agreement** 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.

**Agreement** 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. **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

**Agreement** 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** 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. **Agreement** 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.

**Agreement**For enh. Type 3 HARQ-ACK CB(s), support dynamic selection based on indication in the triggering DCI of one of at least one enh. Type 3 HARQ-ACK CB(s). * Each of the at least one enh. Type 3 HARQ-ACK CBs is at least defined by RRC configuration This includes the option to configure all DL HARQ processs of all configured CCs as one enh. Type 3 HARQ-ACK CB (resulting in same structure and size as the Rel-16 Type 3 HARQ-ACK CB)
* This includes UE capability signaling (value range {1…X}) on the maximum number of supported simultaneously configured enh. Type 3 HARQ-ACK CBs that can be dynamically indicated
* Details including the value of X are FFS

**Agreement**The following enhanced Type 3 CB types of smaller size are supported, the CB to contain either: * the HARQ processes of a subset of configured CCs, or
* a subset of configured HARQ processes (specific to CCs)

FFS: additional enh. Type 3 CB types**Agreement**For Rel-17 one-shot triggering for HARQ-ACK re-transmission, 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
 |

* 1. Summary of companies input in their contributions

**Enhanced Type 3 CB:**

**Number of configurable Enh. Type 3 CBs X (depending on UE capability signaling):**

* 1: Ericsson [2] (moderator note, this is against the RAN1#106-e agreement) ) (To Moderator/All: Please see Ericsson comment that it is not against the agreement)
* 3: Spreadtrum [4] (R16, per CC and per HARQ & CC one each), OPPO [6] (?, up to 2 bits)
* 4 or 8: CMCC [11]
	+ *Moderator comment*: one state would need to be reserved as ‘no trigger’, therefore 2 or 3 bits would result in 3 and 7, respectively.
* 8: Samsung [16] (or 16)
* 16: Nokia/NSB [8], Samsung [16] (or 8)

**Enhanced Type 3 CB types that can be configured:**

* **Of specific SPS configurations:**
	+ Yes: vivo [5], ETRI [20] (based on activation)
	+ No: Nokia/NSB [8], Samsung 15], LTE [25] (… no additional)
* **Remove the configuration option as subset of CCs, as this can be done also with per HARQ process & CC (to simplify RRC & specification):** Nokia/NSB [8]
* **Support in addition HARQ processes of all activated CCs:** ETRI [20]
	+ This includes the need for defining a reference time for SPS activation / release & CCs: ETRI [20]
* **Triggering DCI to indicate at least requested CCs, and starting HARQ ID per requested CC**: Qualcomm [27]

**PHY priority related clarification of enh. Type 3 CB restriction (change earlier agreement in red):** OPPO [6]

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| **Agreement** 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 **with the same priority index as the enhanced Type3 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~~**.  |

**Rel-17 enhanced Type 3 HARQ-ACK codebook of smaller size triggering details:**

* **Number of triggering bits / fields added to DCI:**
	+ Reuse the legacy ‘*one-shot HARQ-ACK request*’ for triggering: Huawei / HiSi [1], Ericsson [2], Nokia/NSB [8], Samsung [15], Intel [17], DoCoMo [18], Sony [19], Panasonic [21], Qualcomm [27], vivo [5]
	+ ~~1-bit trigger in DCI: vivo [5]~~
	+ New dedicated N-bit bitfield (N=log2 (M+1) for M configured enh. Type 3 CBs): Spreadrum [4], OPPO [6] (N<=2bits), CMCC [11] (?), TCL [13], Samsung [15]
	+ ~~Several new DCI bitfields defining the enh. Type 3 CB to be triggered: Qualcomm [27] (at least requested CCs, and starting HARQ ID per requested CC):~~
* **Scheduling PDSCH with triggering DCI:**
	+ **If one enh. Type 3 CB is configured,** the DCI can also be used to schedule PDSCH – if more than one configured, the DCI cannot schedule PDSCH and some unused field is used to indicate which enh. Type 3 CB: Huawei / HiSi [1], vivo [5], DoCoMo [18], Panasonic [21], Interdigital [23]
	+ **If PDSCH is scheduled**, only one (defined) Type 3 CB can be triggered. Otherwise (i.e., if PDSCH is not scheduled), some unused DCI field is used to indicate the Type 3 CB: Nokia/NSB [8] (defined = lowest ID), Intel [17] (defined = first entry), Sony [19] (defined = RRC configured)
	+ **If PDSCH is scheduled,** a N bit triggering field is used. Otherwise, some unused DCI field is used to indicate the Type 3 CB: Samsung [15]
		- *Moderator comment*: Would this mean the DCI size to change (1bit versus N-bit triggering field) depending if PDSCH is scheduled or not!??
	+ **PDSCH can be always scheduled:** Spreadtrum [4] (using N-bit triggering field), OPPO [6], Qualcomm [27] (?)

**Separate CBG / NDI configurability:**

* **For different enh. Type 3 CBs:**
	+ Yes: Ericsson [2] (for Rel-16 and the single enh. Rel-17 Type 3 CB), OPPO [6], Nokia/NSB [8], LGE [25]
	+ No: ETRI [20] (?)
* **For DCI format 1\_1 and 1\_2:**
	+ Yes: vivo [5] (see Sec. 2.5 RRC parameters)
	+ No: ETRI [20] (?)
* **Per PHY priority:**
	+ Yes: Samsung [15], Apple [26]
	+ No: Nokia/NSB [8], ETRI [20] (?), FGI/APT [22] (should be the maximum of *maxCodeBlockGroupsPerTransportBlock* in *PDSCH-CodeBlockGroupTransmission* for LP and HP)

**Separate enh. Type 3 CB configurations for DCI format 1\_1 and 1\_2 (i.e., different CCs or HARQ processes):** OPPO [6]

**Interaction of SPS HARQ-ACK deferral and enh. Type 3 CB:** DoCoMo [18]

* SPS HARQ-ACK deferral is stopped / dropped before the PUCCH slot where an enhanced Type 3 CB has been triggered: DoCoMo [18] (see Fig. 3 in Sec. 2.2.1),

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

**(Enh.) Type 3 CB and one-shot triggering simultaneously configured:**

* Yes: Huawei/HiSi [1], Nokia/NSB [8]
* No: OPPO [6]

**Support triggering using DCI format 1\_2 (in addition to DCI format 1\_1):**

* Yes: Ericsson [2], Nokia/NSB [8] (separate RRC configuration)

**Triggering details:**

* **Number of triggering bits and PDSCH scheduling**
	+ Uses 1-bit trigger and does not schedule PDSCH if trigger bit is set to ‘1’/’trigger’ (some unused field used to indicate the ‘slot offset’): Huawei/HiSi [1], Spreadtrum [4], vivo [5], Nokia/NSB [8], CATT [9], DoCoMo [18], Panasonic [21]
	+ 2-bit triggering field: OPPO [6]
		- *Moderator comment*: 1bit is not sufficient, as this would not enable the dynamic indication of the PUCCH to be re-transmitted. With 2bits, 3 different PUCCH occasions can be dynamically indicated.
	+ 1bit trigger and can schedule PDSCH: Ericsson [2] (details on the indication of the HARQ-ACK codebook missing), Interdigital [23]
* **Unified triggering for enh. Type 3 CB and one-shot triggering:** 1-bit triggering field in combination some bit fields to differentiate enh. Type 3 CB triggering and ‘one-shot HARQ re-transmission’: Huawei / HiSi[1], vivo [5], Nokia/NSB [8], CATT [9], LGE [25] (one field introduced to indicate the scheme)
	+ Reuse the legacy ‘one-shot triggering’ field: Huawei / HiSi[1], Nokia/NSB [8]
	+ Use separate fields for enh. Type 3 CB & one-shot triggering: Huawei/HiSi [1] (e.g., HPN for enh. Type 3 CB selection, MCS field for one-shot ‘slot offset’)
	+ Use one bit in a field of some unused DCI field to differentiate Type 3 & one-shot, and the same unused field to indicate Type 3 CB selection or slot offset for one-shot re-tx: Nokia/NSB [8]
	+ Introduce a field to differentiate: LGE [25]
* **Implicit triggering of HARQ-ACK re-transmission based on indication of two HARQ-ACK transmission occasions in DCI:** Lenovo/Motorola [24]
	+ 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.
* Triggering before the slot of the ‘PUCCH / HARQ-ACK dropping’ is supported: ZTE [3], Nokia/NSB [8]
	+ ZTE [3]: The cancelled HARQ-ACK codebook should be triggered for retransmission as early as possible after the conflict is determined, for example, the earliest trigger starts after the decoding of PDCCH corresponding to the high-priority PUCCH.

**‘Slot-offset’ definition:**

* 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: ZTE [3] (positive & negative values supported), OPPO [6], CATT [9], Samsung [15], DoCoMo [18], Sony [19], FGI/APT [22], Lenovo/Motorola [24]. LGE [25]
* Alt. 2: The PUCCH slot offset defines the (backward / negative) offset between the new PUCCH slot for transmission and the PUCCH slot of the HARQ-ACK codebook to be re-transmitted: Huawei / HiSi [1], Spreadtrum [4], vivo [5], Nokia/NSB [8], Panasonic [21]
* Alt. 3: Indication of ‘last’ or ‘earliest’ canceled HARQ CB: Qualcomm [27]
* Details & other:
	+ only slots with valid PUCCH resources are indicated: Samsung [15]
		- *Moderator*: should this be ‘counted’ instead of ‘indicated’??
	+ Interaction with PUCCH carrier switching of different numerologies: DoCoMo [18]
		- *If PUCCH carrier switching is enabled, PUCCH cell/carrier index of the “old HARQ-ACK CB” needs to be explicitly or implicitly indicated. Slot offset is interpretated based on the numerology of the PUCCH cell/carrier of the “old HARQ-ACK CB”.*
	+ The granularity of the target PUCCH offset *KReTx* follows the smallest *K*1 granularity of the configured HARQ-ACK PUCCHs: Sony [19]
	+ The DCI triggering the 1-shot ReTx CB also indicates the starting OFDM symbol relative to the indicated slot/sub-slot of the target PUCCH: Sony [19]
		- *Moderator comment*: It seems, that the problem / assumption this proposal is based on is not valid. As there can be only a single PUCCH with HARQ per slot (for slot-based PUCCH) or per sub-slot. And they would need to be of different priority (i.e., there the priority indication comes into play). I hope the understanding of the ‘slot offset’ is in number of slots (for slot-based PUCCH config) or sub-slots (for sub-slot based PUCCH config)
	+ Unit of the slot offset is according to slot length (SCS) configuration for the PUCCH: LGE [25]

**Multiplexing of re-tx HARQ-ACK CB and another initial Type 1/Type 2 HARQ-ACK CB:**

* For Type 1 CB:
	+ Support multiplexing (appending): Huawei/HiSi[1], vivo [5], NEC [7] (optimization possible), CATT [9] (FFS enhancements), DoCoMo [18] (of the same PHY priority), ETRI [20] (of the same priority)
	+ Do not support multiplexing: Nokia/NSB [8], OPPO [6]
	+ Details:
		- 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 [8]
		- Optimize the 2 Type1 CBs to avoid redundant information (union of k1 sets and k1’=k1+slot\_offset): NEC [7]
* For Type 2 CB:
	+ Support multiplexing (appending): Huawei/HiSi[1], vivo [5], Nokia/NSB [8], CATT [9] , DoCoMo [18] (of the same PHY priority), ETRI [20] (of the same priority)
	+ Do not support multiplexing: OPPO [6]
	+ Details:

**HARQ-ACK codebooks size ambiguity of CB to be re-transmitted (for Type 2 CB):**

* Use the T-DAI mechanism to indicate size of the HARQ-ACK codebook to be re-transmitted in the triggering DCI: Huawei/HiSi [1], NEC [7] (incl. total number of HARQ-ACK bits for mux with initial HARQ), Intel [17]
* Size field in the trigger DCI to indicate the size for HARQ-ACK codebook in the PUCCH to be retransmitted: ZTE [3]
* All information about CB type and its size needs to be provided in the triggering DCI, or the UE may assume some default parameters, or may drop transmission of this requested PUCCH: Intel [17]

**Joint operation of Rel-17 intra-UE multiplexing and one-shot triggering:** OPPO [6]

* If both one-shot triggering for HARQ-ACK retransmission and Rel-17 intra-UE multiplexing is configured, a PUCCH carrying both HP HARQ-ACK and LP HARQ-ACK can be triggered for one-shot retransmission: OPPO [6]

**Joint operation of SPS HARQ-ACK deferral and one-shot triggering:** DoCoMo [18]

* the deferred SPS HARQ-ACK can be triggered for one-shot HARQ-ACK retransmission: OPPO [6]
	+ The whole HARQ-ACK codebook is retransmitted without dropping the HARQ-ACK bits that exceed the maximum deferral timing
	+ *Moderator comment*: Another option would simply be to not define any specific (& complicated) handling here but assume there is no joint operation. The gNB can always trigger the one-shot HARQ-ACK re-transmission from the initial PUCCH slot where the deferral had been identified, without needing to consider any target PUCCH slot related procedures including maximum SPS deferral values of the different SPS HARQ-ACK information.
* Allow multiplexing of SPS HARQ-ACK deferred information and one-shot triggered HARQ-ACK information (i.e., PUCCH slot with a one-shot triggered HARQ-ACK is regarded as a potential target PUCCH slot): OPPO [6]
* one-shot triggered new retransmission should not impact deferring for SPS HARQ-ACK bits with different PHY priority from the priority indicated by the triggering DCI: DoCoMo [18]
* deferred SPS HARQ-ACK bits with same PHY priority from initial PUCCH slots and before the new retransmission PUCCH slot will be dropped: DoCoMo [18]
* Only initial HARQ-ACK bits in the indicated “old HARQ-ACK CB” will be retransmitted in the new retransmission PUCCH triggered by one-shot triggering DCI: DoCoMo [18]
* UE assume no SPS HARQ-ACK deferral for One-shot HARQ-ACK re-transmission. In other words, UE performs One-shot HARQ-ACK re-transmission as if no SPS HARQ-ACK deferral occurs: LGE [25]

**Joint operation / interaction of enh. Type 3 CB and one-shot triggering:**

* Support: Huawei / HiSi[1], vivo [5], Nokia/NSB [8], CATT [9], DoCoMo [18], LGE [25]
* It is not expected that (enhanced) type 3 HARQ-ACK CB is scheduled to be transmitted in the same PUCCH slot as the one-shot triggered new retransmission PUCCH: DoCoMo [18]

**Other:**

* The dynamic triggering is to request for the last dropped HARQ-ACK codebook: Ericsson [2], Interdigital [23]
	+ *Moderator comment*: this is against the RAN1#106-e agreement of dynamic indication of the HARQ-ACK codebook to be re-transmitted.
* Further study the impact of dynamic requested HARQ-ACK retransmission on current DRX mechanism: NEC [7]
* As a capability, the maximum time window or the maximum number for keeping HARQ codebooks can be reported: ETRI [20]
	+ *Moderator comment*: this is not handled in AI 8.3.1.1 but in the UE feature discussions
* The retransmitting HARQ codebook can consist of only valid HARQ-ACK bits: ETRI [20] (for BWP change)
* 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: Apple [26]
	+ *Moderator comment*: we have an agreement from RAN1#106-e preventing such operation. Please check the chairman’s notes.
* 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: Qualcomm [27]

**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 [5] (then readily available)

**Autonomous one-shot HARQ-ACK re-transmission for all or a subset of HARQ processes in an earlier CG-PUSCH resource:** Lenovo/Motorola [24]

**Automatic re-tx of canceled HARQ-ACK (if multiplexed on PUSCH) on the PUSCH re-transmission:** Qualcomm [27]

* 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 NDI & 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 [27]

* 1. 1st Round of email discussions

First let’s check, if we support simultaneous configuration / operation of the two HARQ re-tx schemes which may have an effect on the further dynamic indication discussions. As this is a ‘Yes / No’ decision, the moderator brings forward a proposal directly (if not acceptable, then clearly no support):

**Proposal 3.2.1: Support (Enh.) Type 3 CB and one-shot HARQ triggering to be simultaneously configured for a UE.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, Sony, LG Huawei/Hisi, DOCOMO |
| Objecting companies | Samsung, CATT, vivo, ZTE |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Intel | The mechanisms share similar goals and design aspects and are subject to different UE capabilities. In our view, joint operation of these features is not expected. Suggest not optimizing this case. |
| Qualcomm | Agreement with IntelAs explained in the contribution, these two features can be complementary and they can serve different scenarios. Very important details on both features are still missing. This question can be discussed at the next round when hopefully the other DCI fields are described. This proposal comes from nowhere. How many companies support this proposal? Companies might have a unified view for both solutions, but this does not mean that they see necessarily a joint configuration of both.**CATT, Huawei and OPPO listed as supporter of this proposal. There is not a proposal for simultaneous configurations in Huawei’s contribution stating this. Can CATT, Huawei and OPPO clarify their stance?** |
| Ericsson | Should be discussed at a later stage.* We are in general supportive, but we rather to wait until there is more clarity on the design of each feature, specially with respect to DCI.
 |
| Samsung | No functional need – only additional spec impact to indicate which to use. |
| Panasonic | We share the similar view with Intel.  |
| Sony | If the UE supports both retransmission methods, we do not see why there should be a restriction in the configuration. |
| CATT | We do not see the need to simultaneously (Enh.) Type 3 CB and one-shot HARQ triggering. In addition, both proposal 3.2.8 and 3.2.13 propose to reuse the legacy 1-bit ‘one-shot HARQ-ACK request’ for triggering (Enh.) Type 3 CB and one-shot HARQ triggering respectively, which seems assume they are not configured simultaneously. |
| vivo | We agree with Intel. |
| LG  | Though we decided to support two of features as compromise, we also believe each feature has different pros and cons. For now, we think it is safer to allow configuring both features simultaneously.  |
| ZTE | We can not estimate how devices handles the two function simutaneouly. |
| Huawei/Hisi | Different schemes can be applied for different cases. E.g., Type 3/Eng. Type 3 is used for triggering re-tx of loads of dropped SPS HARQ-ACKs due to TDD collision, and one-shot re-tx is used for triggering re-tx of dropped HARQ-ACKs in one PUCCH due to prioritization/cancellation.As these two features are not conflict to each other in functionality, we donot see the reason not to configure both for one UE.**To CATT**: As an example for the DCI not scheduling PDSCH, a distinguishing flag, e.g., 1 bit, can be introduced (by reusing the unused bit field) to trigger either enh.Type 3 or one-shot. There is no need to trigger both by one DCI. |

**Enhanced Type 3 CB**

**Issues with RRC impact / configurability**

It is still open, how many simultaneously configurable enhanced Type 3 CB a UE would be supporting. As this may depend on UE capabilities, it may be better to utilize UE capability signaling and aim for a larger number for higher end UEs and being future proof there.

**Proposal 3.2.2: The number of simultaneously configurable enhanced Type 3 CB is indicated by the UE through UE capability signaling with a value range of {1…16}**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, Intel, Samsung, Panasonic, vivo, ZTE Huawei/Hisi, DOCOMO… |
| Objecting companies | Ericsson, Sony |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Nokia/NSB | We think we should go for a larger number to be future proof here.  |
| Intel | Fine with a larger number 16, and with other values e.g. 4,8,10…16 |
| QC | Support 1 size. In this case the rest of the DCI fields can be used for scheduling PDSCH.Bringing this proposal based on only 6 out 28 companies expressing their opinion on this matter and moreover, with almost each of the 6 companies suggesting a different value is not wise discussion moderation. This proposal to be discussed later. |
| Ericsson | Our view is that X>1 is not beneficial.We have analysized and showed in our contribution that X>1, does not bring any benefit. We are even doubtful fro X=2 and don’t see what is the benefit of X=16.To Moderator: We think we should first discuss if there is any benefit first, before going into details design.Moderator has commented that Ericsson proposal is against previous agreement.We explain here our understanding of the agreeemnent: * The main bullet says “dynamic selection based on indication in the triggering DCI). However, in the first bullet, we say X=1 is supported (at least .. ). Then for this case, considering the description for proposed 25-6, it is clear that the field in DCI, only triggers Type-3 (the one with reduced size). And does not do any dynamic selection.
* Then, the second bullet, discusses capability. The way we understand second bullet is that it is about capability. For example, if X=3, we need to define 3 capability, since range is {1,2,3}.
* Lastly, X is FFS.

Clearly X=1 is supported from second bullet. But we need to discuss larger value of X as it says X is FFS. We don’t see such a statement in agreement. Moreover, as for X=1, “dynamic indication based on trigeerign DCI” is understood as only triggering DCI, we don’t think the agreement implies X>=2 is supported.**Agreement**For enh. Type 3 HARQ-ACK CB(s), support dynamic selection based on indication in the triggering DCI of one of at least one enh. Type 3 HARQ-ACK CB(s). * Each of the at least one enh. Type 3 HARQ-ACK CBs is at least defined by RRC configuration This includes the option to configure all DL HARQ processs of all configured CCs as one enh. Type 3 HARQ-ACK CB (resulting in same structure and size as the Rel-16 Type 3 HARQ-ACK CB)
* This includes UE capability signaling (value range {1…X}) on the maximum number of supported simultaneously configured enh. Type 3 HARQ-ACK CBs that can be dynamically indicated
* Details including the value of X are FFS

In our understanding, if Ue is configured with X>1 reduced sized code book, UE can dynamically select between them. This is also reflected in the proposed 25-6 UE feature by Moderaotr.

|  |  |  |  |
| --- | --- | --- | --- |
| 25-6 | Enhanced type 3 HARQ-ACK codebook feedback | 1. Support feedback of enhanced type 3 HARQ-ACK codebook, triggered by a DCI 1\_1 and DCI format 1\_2 (for a UE supporting DCI format 1\_2, 11-1)2. Support configuration of up to X enhanced type 3 HARQ-ACK codebooks. 3. Support feedback of a dynamically selected enhanced type 3 HARQ-ACK codebook based on triggering information in DCI 1\_1 and DCI 1\_2 (for a UE supporting DCI format 1\_2, 11-1)4. Support transmission of enhanced type 3 HARQ-ACK codebook using the first or second PUCCH configuration based on PHY priority indication in the triggering DCI (for a UE supporting two HARQ-ACK codebooks / PUCCH config in 11-4) | For component 2, the UE indicates its capability in the number of enhanced type 3 HARQ-ACK codebooks: {1,...,X}For component 3, the dynamic indication is only supported if the UE for component 2 supports more than one enhanced type 3 HARQ-ACK codebook to be configured |

 |
| Samsung | We do not see any need for that capability – it only introduces unnecessary complexity - a UE that can generate the Rel-16 Type-3, can generate any subset of it. However, OK to proceed for progress and as this is already agreed in principle.  |
| Moderator | @QC & Ericsson: Please note that we have an agreement to support more than one to be configured, which can be dynamically indicated. Please respect existing RAN1 decisions here – all companies have the feeling that sometimes something is not needed. Please, let’s be constructive and see what we do having an existing agreement to have more than 1 (i.e. X>1)  |
| Ericsson2 | Some follow-up to Moderator/all* We do respect previous agreement and we are constructive (such a comment is not appreciated).
	+ That is why we explained clearly and in details what is our understanding of the previous agreement. Reviewing the agreemets made so far, I assume Moderator refers to the agreement that we discussed in our comment. If Moderator is referring to another agreement, please let us know which one it is.
	+ Consideirng many of the proposals in this summary are clarifying the previous agreement, the same efforts should at least taken here.
* We requested to have a discussion on benefits of X>1.
	+ We explained the “flexibility claim” is not justified. At least a proper discussion on understanding WHY we are doing things has the highest importance in our view.
 |
| Sony | 16 seems excessive considering we also have the one-shot ReTx method. We think perhaps 4 or 8 are sufficient. |
| vivo | We support the maximum number of 16 to make this feature useful.  |
| Moderator | @EricssonI am referring to exactly the same agreement, but the agreement does not talk about dynamic indication of the triggering itself, but it talks about dynamic indication of the selection of one enh. Type 3 CB. Please note that for X=1, there is no dynamic selection (as there is nothing to select, as then only a single one can be configured):**Agreement**For enh. Type 3 HARQ-ACK CB(s), support dynamic selection based on indication in the triggering DCI of one of at least one enh. Type 3 HARQ-ACK CB(s). * Each of the at least one enh. Type 3 HARQ-ACK CBs is at least defined by RRC configuration This includes the option to configure all DL HARQ processs of all configured CCs as one enh. Type 3 HARQ-ACK CB (resulting in same structure and size as the Rel-16 Type 3 HARQ-ACK CB)
* This includes UE capability signaling (value range {1…X}) on the maximum number of supported simultaneously configured enh. Type 3 HARQ-ACK CBs that can be dynamically indicated
* Details including the value of X are FFS
 |

**Enhanced Type 3 CB types:**

Two CB types have been agreed: the CB contains the HARQ processes of a subset of configured CCs or a subset of configured HARQ processes (specific to CCs). Two companies suggest defining additional CB types, whereas three companies suggest to not add any new CB types. As a consequence, the following is proposed:

**Proposal 3.2.3: No additional enhanced Type 3 CB ‘types’ (such as activated CCs, of specific SPS configurations, etc.) in terms of RRC configuration are supported.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, Intel, QC, Samsung, Panasonic, Sony, CATT, vivo,TCL, LG, ZTE Huawei/Hisi, DOCOMO, China Telecom… |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Intel | After further checking, we don’t think MAC layer maintains separate HARQ processes for SPS and Dynamic DL scheduling, although they are not related. Thus, it is sufficient to handle by a sub-set of HARQ processes. |
| Ericsson | OK |
| Samsung | The motivation for such enhancements may exist for the Rel-16 Type-3 but it is substantially reduced/eliminated for the Rel-17 Type-3. They remain important for the mandatory Type-1 CB but that can be considered some other time. |
| vivo | With the understanding that by proper configuration, the CB corresponding to specific SPS configuration(s) can be achieved, we can accept the proposal. |
|  |  |

One company raised the issues, that by having a per HARQ process (and per CC) configurability the 2nd option of configuring per CC is not really needed (as the first option can achieve the same), and will only increase RRC parameter complexity and specification complexity in general. Let’s see if this could be acceptable for companies:

**Proposal 3.2.4: To simplify the RRC structures and specification complexity, remove the option of configuring the enhanced Type 3 CB as a subset of CCs, as the same configurability is already provided by the option to configure per HARQ processes (specific to CCs) already.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, QC, Sony, CATT, ZTE… |
| Objecting companies | Samsung |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Nokia/NSB | Having the two options for configuration will not reduce the RRC overhead as the choice of having two ways to configure will not reduce the RRC overhead (as needs to be planned for the largest size anyhow). But will simplify the specification work in 38.213 clearly (and having less RRC parameters on top).  |
| Intel | This looks like a detail of RRC signaling implementation. May be this may be turned into a ‘conclusion’, that the previous agreement may be implemented by a single signaling structure? |
| Ericsson | Ok to simplify to only “subset of HARQ processes per CC of a subset of CCs” which generally includes “subset of CCs” or “subset of HARQ processes” |
| Samsung | A NW should be able to indicate the CCs for which the NW wants HARQ-ACK feedback (e.g. that also relates to proposal 3.2.3 for not optimizing for activated vs. configured CCs – or can indicate skipping CCs for which there was no scheduling, …). Also, a NW should be able to choose the RRC signalling it prefers instead of not having a choice.  |
| Panasonic | In our view, the RRC parameter details would be up to RAN2 discussion. |
| vivo | We share Panasonic’s view. |
| DOCOMO | Share similar view as Interl that it seems more like RRC configuration details.In our understanding, for “HARQ processes of a sub-set of CCs”, it is possible that HPNs are not configured but only sub-set of CCs are configured. Then all configured HPNs for the sub-set of CCs will be included in the enhanced type 3 CB. It can save RRC overhead than explicitly listing all the HPNs for these CCs. |

**CBG / NDI configurability flexibility and DCI format 1\_2 handling:**

There had been discussions by different companies on the independent CBG/NDI configurability in terms of PHY priority, different HARQ-ACK codebooks. These are basically binary decisions and therefore a proposal is directly brought forward.

First, we had an agreement of the same Type 3 CB structure (& size) for different priorities. When having a different CBG configuration this clearly would violate the earlier agreement (in terms of CB size). Therefore, the following proposal is brought forward:

**Proposal 3.2.5: For one enhanced Type 3 HARQ-ACK CB, the same CBG and NDI configuration applies to both PHY priorities following the RAN1#106-e agreement.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, Intel, Samsung, Panasonic, Sony, CATT, vivo ,TCL Huawei/Hisi, DOCOMO, China Telecom… |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Ericsson | OK |
|  |  |
|  |  |
|  |  |
|  |  |

Several companies propose to support separate CBG / NDI configuration for different entries in the list of configured enh. Type 3 CBs (which actually would be according to the draft RRC parameter list from RAN1’106-e).

|  |  |  |
| --- | --- | --- |
| pdsch-HARQ-ACK-enhType3 | Configure one enhanced Type 3 HARQ-ACK codebook (from the list / set of enh. Type 3 HARQ-ACK codebooks) | {pdsch-HARQ-ACK-enhType3Index,CHOICE {pdsch-HARQ-ACK-enhType3perCC, pdsch-HARQ-ACK-enhType3perHARQ}, pdsch-HARQ-ACK-enhType3NDI, pdsch-HARQ-ACK-enhType3CBG} |

Anyhow, let’s check if we support separate configurability here. Otherwise, the current draft RRC parameter needs to be changed:

**Proposal 3.2.6: The CBG and NDI usage can be independently configured for different enhanced Type 3 HARQ-ACK CBs.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, Intel, Samsung, Panasonic, Sony, CATT, TCL,LG, DOCOMO… |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Ericsson | OK |
|  |  |
|  |  |
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One company proposes to enable the configuration of different enh. Type 3 CB lists (incl. NDI & CBG) when using triggering of DCI format 1\_1 and 1\_2. Again, this is more a Yes/No decision here, but as the current RRC parameter lists does not contain this, let’s then check if such additional flexibility would really be needed (specifically, as the number of configurable enh. Type 3 CBs across both DCI formats may still be limited by the UE capability).

**Proposal 3.2.7: The same set of enhanced Type 3 CBs (incl. CBG and NDI configuration) is applied for triggering using DCI format 1\_1 and 1\_2.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, Intel, Samsung, Panasonic, Sony, CATT, TCL, LG Huawei/Hisi, DOCOMO, China Telecom… |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Nokia/NSB | We don’t see a need to differentiate the Type 3 CB depending on the DCI it is triggered from. Let’s keep it simple here.  |
| Ericsson | OK. No need for complication |
| vivo | No strong view, but necessary to clarify it. |
|  |  |
|  |  |

**Triggering details and ability to schedule PDSCH:**

A majority of companies (9 vs 5) suggest using a 1-bit trigger, and 8 of these 9 companies suggest to reuse the existing Rel-16 triggering field for this purpose. Therefore, the following is proposed:

**Proposal 3.2.8: Reuse the legacy 1-bit ‘*one-shot HARQ-ACK request*’ for triggering indication of the enhanced Type 3 HARQ-ACK CB of smaller size.**

* **At least if only a single enhanced Type 3 HARQ-ACK CB is configured, the triggering DCI with the triggering bit set to ‘1’ is also able to schedule PDSCH.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, Intel, QC, Samsung, Panasonic, Sony, CATT, vivo,TCL, ZTE Huawei/Hisi, DOCOMO… |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Ericsson | OK. We understand the proposal as If only a single enh. Type-3 is condifered, basically the behaviour is as Rel-16 where the Type-3 code book, is the single enhanced (reduced size). If different understanding, we need to discuss. |
| vivo | Correct our positions in previous section 3.1 of the summary, see below**Rel-17 enhanced Type 3 HARQ-ACK codebook of smaller size triggering details:** * **Number of triggering bits / fields added to DCI:**
	+ Reuse the legacy ‘*one-shot HARQ-ACK request*’ for triggering: Huawei / HiSi [1], Ericsson [2], Nokia/NSB [8], Samsung [15], Intel [17], DoCoMo [18], Sony [19], Panasonic [21], Qualcomm [27], vivo [5]

~~1-bit trigger in DCI: vivo [5]~~ |
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Assuming the 1-bit triggering is acceptable, the question is how to deal with the case that more than one enh. Type 3 CB is configured, what are the PDSCH scheduling restrictions (as some unused field will be needed for selection of the Type 3 CB). Two approaches were discussed by different companies – one simpler but slightly more restrictive, one slightly more complicated (additional condition) but providing more PDSCH scheduling flexibility. Please provide your input below:

**Question 3.2.9: If more than one enhanced Type 3 HARQ-ACK codebook is configured and 1-bit triggering indication is used, the triggering DCI with the single triggering bit set to ‘1’**

* **Alt. 1: is not able to schedule PDSCH.**
	+ **Some unused DCI field is used to indicate which enhanced Type 3 HARQ-ACK codebook is triggered.**
* **Alt. 2: is able to scheduled PDSCH:**
	+ **If PDSCH is being scheduled (i.e., valid FDRA), the DCI triggers the first enhanced Type 3 HARQ-ACK codebook from the list;**
	+ **If PDSCH is not scheduled (i.e., FDRA all ‘0’ or ‘1’), some unused DCI field in the triggering DCI is used to indicate which enhanced Type 3 HARQ-ACK codebook is triggered**
* **Alt. 3: Other**

|  |  |
| --- | --- |
| Alt. 1 | CATT, vivo Huawei/Hisi |
| Alt. 2 | Nokia/NSB, Intel, Panasonic, Sony, ZTE, DOCOMO (with some updates) |
| Alt. 3 – other | Samsung, LG |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Nokia/NSB | Alt. 2 allows also to schedule PDSCH at the same time. Has only advantages compared to Alt. 1 from our perspective.  |
| Intel | Alt. 2 is preferred. Utilizing the DCI scheduling PDSCH with one CB type is much less restrictive than prohibiting PDSCH scheduling at all. Alt. 2 fully covers Alt. 1 capabilities. |
| QC | As expressed since the beginning the use of multiple Rel. 17 Type 3 HARQ CB sizes is not justified. Rel. 16 Type 3 HARQ CB allows PDSCH scheduling. Same approach to be followed in Rel. 17. |
| Ericsson | As we commented before, we need to discuss first to decide if it is supported or not. |
| Samsung | The tradeoffs for having non-scheduling or scheduling DCI depends on the NW choice for when to use enhanced Type-3. If used all the time, having a scheduling DCI makes sense. If used only for HARQ-ACK retransmissions, a non-scheduling DCI makes sense as the additional overhead will not be unnecessary only for DCI format 1\_1/1\_2 but also for DCI formats 0\_1 or 0\_2 (more likely for the latter) due to size matching.Alt. 2 is a very specific solution that does not address the above.No need to define new designs when the Rel-16 ones for indicating SCell dormancy are directly applicable (only “SCell dormancy” needs to change to “HARQ-ACK retransmission”). |
| Moderator | @QC & Ericsson: Please note that we have an agreement to support more than one to be configured, which can be dynamically indicated. Please respect existing RAN1 decisions here – all companies have the feeling that sometimes something is not needed. Please, let’s be constructive and see what we do having an existing agreement to have more than 1 (i.e. X>1)  |
| Ericsson2 | Some follow-up to Moderator/all (similar to Proposal 3.2.9)* We do respect previous agreement. (such a comment is not appreciated) and we are constructive.
	+ That is why we explained clearly and in details what is our understanding of the previous agreement. Reviewing the agreemets made so far, I assume Moderator refers to the agreement that we discussed in our comment. If Moderator is referring to another agreement, please let us know which one it is.
	+ Consideirng many of the proposals in this summary are clarifying the previous agreement, the same efforts should at least taken here.
* We requested to have a discussion on benefits of X>1.

We explained the “flexibility claim” is not justified. At least a proper discussion on understanding WHY we are doing things has the highest importance in our view.  |
| Panasonic | Alt.2 seems to cover Alt,1 functionality. |
| Sony | It should be noted that Rel-16 Type 3 CB allows the network to indicate, via FDRA, whether to schedule or not schedule a PDSCH. Hence, Alt. 2 perserves this mechanism.  |
| vivo | Alt.2 has limted flexibility for scheduling DCI when multiple Type 3 codebook size is configured, but requires more specification efforts. So, we prefer Alt.1.  |
| LG | We prefer to introduce new dedicated DCI field for new features.  |
| ZTE | If PDSCH is not scheduled, there are many blank DCI overhead can be reused. Why not considering the dynamic indication for multiple enhanced type-3 CBs, it seems more efficient. |
| Huawei/Hisi | Alt.1 already provides sufficient flexibility between PDSCH scheduling and enh. Type 3 CB indication. For Alt.2, more alternatives of the first bullet may also be raised, which may lead to more comparisons and discussions, such as: If PDSCH is being scheduled (i.e., valid FDRA), the DCI triggers the **union of all enhanced Type 3 HARQ-ACK codebooks** from the list. |
| Moderator | @Huawei: do agree that some more discussion then on the ‘fallback’ Type 3 CB would be needed, but having the first in the list to allows the gNB to select which one it thinks would be most important (based on configuration). Of course an option would be also to have the Rel-16 Type 3 CB (all HARQ & all CCs) triggered which would be maybe better than some union of something.But at least for one triggering case the PDSCH scheduling could be retained (which seems to be important for some companies, especially those that suggest larger DCI field for the triggeriong).  |
| DOCOMO | We are fine with the principle of Alt 2. But we share similar view as Huawei. Maybe it’s better to determine “Rel-16 legacy type 3 HARQ-ACK CB” as the triggered HARQ-ACK CB when the DCI schedules PDSCH? It seems more compatible to Rel-16 behavior. |

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

We have not agreed yet to support the triggering using DCI format 1\_2, as recognized last time in the RRC parameter discussions. Therefore, the following proposal is brought forward:

**Proposal 3.2.10: Support triggering of one-shot HARQ re-transmission on PUCCH using DCI format 1\_2.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, Intel, QC, Samsung, Panasonic, Sony, CATT, vivo, ZTE Huawei/Hisi, DOCOMO… |
| Objecting companies |  |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Ericsson | We received some comments from Maderator that seems there is a conflict in view. Hence, we rather to sort that out first, and then confirm WA: |
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Two companies discussed that the triggering of the HARQ re-tx should be possible already before the slot where some dropping is happening (to reduce latency, see discussions by ZTE). Let’s check if this could be acceptable for companies:

**Proposal 3.2.11: To reduce HARQ latency, support triggering of one-shot HARQ re-transmission on PUCCH before the initial PUCCH transmission slot (as early as the conflict is determined).**

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| --- | --- |
| Supporting companies | Nokia/NSB, Intel, Panasonic,vivo, ZTE Huawei/Hisi, DOCOMO … |
| Objecting companies | Samsung, CATT |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| QC | Can you give a realistic scenario with tangible numbers and assumptions? The group needs to specify the feature – far from being specified - before searching for inventive ways to optimize corner cases. How many companies did bring this topic into discussion and a proposal is motivated? |
| Ericsson | OK but We don’t see the need for such proposal. In our view, there was no restciton that it should be triggered “after” conflict that we should discuss if we can trigger before conflict. What is important with repsct to trigger is timeline. |
| Samsung | No real use-case/impact. If at all possible due to timelines, it will only complicate multiplexing procedures which, as much as possible, should not be touched.  |
| Sony | This may be addressed by the range of configurable target PUCCH offset. |
| CATT | We do not see a strong need for the proposal. |
| vivo | Per our understanding, it may be useful for recovering the dropped LP HARQ in advance in case gNB knows there will be HP channel that cancels the LP HARQ or the PUCCH resource for HARQ-ACK is not available |
| ZTE | It is not a timeline issue and will not cause any complicated multiplexing procedure. From previous meeting discussion, it seems companies’ foucs on one-shot DCI is after the initial PUCCH transmission. But it is very possible that one-shot HARQ re-transmission on PUCCH could be before the initial PUCCH transmission slot. The intention is just to allow triggering of one-shot HARQ re-transmission on PUCCH before the initial PUCCH transmission slot besides the case of “after”. Restricting the target PUCCH offset to be only positive or negative is not reasonable if alt.1 in question 3.2.12 is adopted. |

Next, let’s check where companies stand in terms of how the dynamic indication is interpreted for the one-shot HARQ-ACK triggering. Please also take your input to the previous question into account here (when the earliest triggering is possible) when providing your input here:

**Question 3.2.12: Which of the following dynamic indication methods is to be applied for one-shot HARQ re-transmission on PUCCH:**

* **Alt. 1: The dynamic indication defines the offset in number of PUCCH slots between the triggering DCI and the PUCCH slot of the HARQ-ACK codebook to be re-transmitted**
	+ ***Note: if triggering before the initial PUCCH slot is supported, this requires positive and negative offset values in the set of values that can be indicated (i.e., larger value range needed)***
* **Alt. 2: The dynamic indication defines the (backward/negative) offset in number of PUCCH slots between the new PUCCH slot for transmission and the PUCCH slot of the HARQ-ACK codebook to be re-transmitted**
	+ ***Note: Only positive values needed in the set of values that can be indicated***
* **Alt. 3: Indication of ‘last’ or ‘earliest’ canceled HARQ CB**
* **Alt. 4: Other**

|  |  |
| --- | --- |
| Alt. 1 | Samsung, Panasonic (2nd preference), Sony, CATT,TCL, ZTE, DOCOMO |
| Alt. 2 | Nokia/NSB, Intel, Panasonic (1st preference), vivo Huawei/Hisi, DOCOMO… |
| Alt. 3  | QC, Ericsson |
| Alt. 4 – other |  |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Nokia/NSB | There is the issue of positive and negative values if we allow the triggering before the initial PUCCH transmission. This means, that a larger value range (depending on when the triggering DCI is received – before or after) is needed for Alt. 1 compared to Alt. 2. So more bits in the triggering DCI will be needed for the indication. We think Alt. 3 is too restrictive.  |
| Intel | Although we vote for Alt.2, we think Alt.1 should also work. We don’t see essential differences between two. Alt.3 in our understanding has issues with Type 2 CBs when some DCIs are missed. |
| QC | Both Alt 1 and 2 require DCI fields. |
| Ericsson | We analyzed and explained in our contribution that “slot-offset” based solutions are not justified in our view, and not worth to complicate DCI design. |
| Samsung | There is no reason to change either the way time offsets have been defined in NR (relative to the time/slot of the DCI reception) or the way for indicating HARQ-ACK timing in a DCI format.  |
| Panasonic | In our view, as far as the number of candidate timings (or slots) is same between Alt.1 and Alt.2, the required bits are same. If Alt.1 has the possibility that the candidate timing does not start just before the PUCCH slot offset, but more earlier timing around triggering DCI, Alt.1 can reduce bitwidth. On the other hand. to indicate too earlier timing increases the complexity of UEs. Therefore, we have slight preference to Alt.2 for simplicity. Alt.1 is also acceptable. |
| vivo | We share the same view as Intel. and Alt.3 actually has issues foir both Type 1and Type 2 CB. We also think both Alt.1 and 2 can work, but select Alt.2 for simplicity.  |
| Huawei/Hisi | The two alternatives are similar in functionality. Alt.2 may need smaller DCI overhead than Alt.1 with respect to the TDD pattern of 4:1/7:3/8:2. Take 4:1 for instance, the potential offset values for Alt.2 may be {5, 10} slots pointing from UL to UL, while for Alt.1 it may be {1,2,3,4,6,7,8,9} slots pointing from DL to UL, to indicate the same range. Though the DCI may not be a big issue w.r.t. Proposal 3.2.13, smaller overhead is still slightly preferred. |
| DOCOMO | We are fine for Alt 1 and Alt 2. Not support Alt 3. |

Similar as for the enh. Type 3 CB, there is a majority of companies thinking that a single 1bit triggering field in the DCI should be sufficient and that not a larger DCI field should be added. Therefore, the following is proposed:

**Proposal 3.2.13: Reuse the legacy 1-bit ‘*one-shot HARQ-ACK request*’ for triggering indication of one-shot HARQ re-transmission on PUCCH.**

* **The triggering DCI with the triggering bit set to ‘1’ is not able to schedule PDSCH.**
* **Some unused bit field in the DCI is used to indicate the HARQ-ACK CB to be re-transmitted.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, Intel, Samsung, Panasonic, CATT, vivo, ZTE Huawei/Hisi… |
| Objecting companies | QC, Ericsson |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| QC | Confusing proposal. Need to clarify first how Rel. 17 Type 3 HARQ CB will be triggered and with which DCI field. Then, if joint configuration allowed and then this one. |
| Ericsson | See the discussion in our contribution |
| Sony | We would like to further consider the possibility for the triggering DCI to also schedule PDSCH. Can we just agree on a single triggering bit for now?, i.e.:**Reuse the legacy 1-bit ‘*one-shot HARQ-ACK request*’ for triggering indication of one-shot HARQ re-transmission on PUCCH.** **The triggering DCI with the triggering bit set to ‘1’** |
| DOCOMO | If the triggering bit is reused, we need to further discuss how UE distinguishes the DCI is for one-shot triggering of HARQ-ACK retransmission on PUCCH, or for (enhanced) type 3 HARQ-ACK CB triggering. We think it is an optimization issue which can be a bit deprioritized. Simply by separate fields is better. |
|  |  |

Some companies discussed that the reliability of the HARQ re-transmission in terms of HARQ CB size ambiguity in case of missed DCI can be helped, if using some total DAI mechanism. Let’s check if this could be acceptable to the group:

**Proposal 3.2.14: For one-shot HARQ re-transmission on PUCCH, support a total DAI mechanism to indicate the size of the HARQ-ACK CB to be re-transmitted.**

* **The total DAI is indicated using an unused DCI field (FFS which field)**

|  |  |
| --- | --- |
| Supporting companies | Sony, LG, ZTE Huawei/Hisi |
| Objecting companies | Samsung, vivo |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Intel | We think the issue of uncertain Type 2 CB size should be considered.As for the solution, there could be additional considerations if we consider ‘new HARQ-ACK’ cases. The new CB and the retransmitted CB need to be multiplexed somehow. In this case, we can consider reusing same t/c-DAI fields and construct a new CB with a mix of retransmitted bits and new bits. But the simple additional of t-DAI for the retransmitted CB can also work. |
| QC | Do not support. The last 2 meetings there is a proposal of solving this issue of LP DCI lost. Why isn’t it brought into discussion? |
| Ericsson | Need more discussion.It is better to understand what is the mechanism ifrst that going into detailsAlt 2 from Nokia tries to address issue of PDSCH scheduling. It could work but seems like an adhoc solution. * If gNB configure multiple enh. Type 3 types, and it would like to dynamically indicate the type, it would not be able to schedule PDSCH at the same time 🡪 not good for scheduling flexibility.
* If it wants to schedule PDSCH at the same time, then only the first configured enh type-3 type is used which may not be the relevant one or maybe the default full-size Rel-16 one 🡪 no benefit of configuring multiple enh. type-3 types.

The other “cleaner” solution is to have a triggering field based on the configuration of enh Type-3, whose size depends on the configuration. This always allow PDSCH scheduling. |
| Samsung | Prefer to keep things simple and not require additional UE functionalities to determine the HARQ-ACK CB to be retransmitted, particularly since there will not be any actual benefit (otherwise, there is a problem when there is no need for the HARQ-ACK CB to be retransmitted). |
| Sony | For Type 2 CB, the likely case for misalignment of number of HARQ-ACK is when the UE misses the last DL Grant associated with the dropped PUCCH. Hence, retransmitting the DAI in the triggering DCI is fine and shouldn’t incur any additional bits as the DAI should have also been configured for the triggering DCI (so that it is same sice as other DL Grant to reduce DCI blind decoding). This is almost a free indicator to avoid misdetection (of the last DL Grant). |
| vivo | Not essential and necessary. It is just for optimization, DCI miss-detction is not a new issue.  |
| ZTE | A total DAI mechanism to indicate the size of the HARQ-ACK CB to be re-transmitted is needed. Below is an example to show if the DCI for PUCCH to be retransmitted is missing, it will cause more complicated problems.From gNB perspective, PUCCH 1 is cancelled and need to be retransmitted. The triggering DCI indicates that PUCCH 1 will be retransmitted. From UE perspective, if UE missed the DCI for the construction of HARQ-ACK codebook in PUCCH 1, UE cannot determine the retransmitted PUCCH from the PUCCH resource set due to the lack of the size of the HARQ-ACK codebook if the DCI for PUCCH1 is missing and the PUCCH indicated by the triggering DCI will not be transmitted eventually. Then, the gNB can’t receive the new PUCCH indicated by the triggering DCI, and the gNB can’t know the reason whether the UE missed the triggering DCI or missed the DCI for PUCCH1. Therefore, the gNB cannot determine whether to retransmit the PDSCHs corresponding to PUCCH 1 or retransmit the triggering DCI. The main reason for gNB can’t distinguish whether the DCI for PUCCH1 is missing or triggering DCI is missing is due to the cancellation of LP PUCCH1, the missing issue of DCI for LP PUCCH1 is covered by the cancellation and this ambiguity is deferred into the step of retransmission of cancelled PUCCH. |
| Huawei/Hisi | Introducing a T-DAI field in the one shot triggering DCI can help the UE to identify the bit number of the re-transmitted HARQ-ACK, in case the DCI scheduling the original HARQ-ACK was missed. Considering the one-shot HARQ-ACK retransmission would use the DCI without scheduling PDSCH, there would be sufficient spare bits in the DCI for introducing the T-DAI field. |
| DOCOMO | We think it is a de-prioritized issue. |

# 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

**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.**Agreement** 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

**Agreement**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 |

* 1. Summary of companies input in their contributions

**Support sub-slot based PUCCH repetition with/using *nrofSlots* (i.e., not using dynamic indication) also for other UCI types than HARQ-ACK, including SR and CSI (5 vs. 2)**:

* **Yes**: ZTE [3], vivo [5], Nokia/NSB [8], CATT [9], Samsung [15]
* **No – only for HARQ-ACK**: Ericsson [2], DoCoMo [18]
* **Details if supported**:
	+ ZTE [3]
		- The UL slot for SR and CSI can be regarded as equal with UL subslot if *subslotLengthForPUCCH* is configured. The modification on specification can imitate the description of UL slot for HARQ-ACK.
		- The starting symbol definition of SR and CSI should align with the boundary of subslot.
		- The periodicity or offset of SR and CSI may need some adjustments.
	+ vivo [5]
		- it can be determined by *startingSymbolIndex* and *subslotLengthForPUCCH*, e.g., the *i*-th repetition position locates in sub-slot *n+i*-1 and starts with a symbol index determined by ( *startingSymbolIndex +*  *subslotLengthForPUCCH \** (*i* -1)) mod $N\_{sym}^{slot} $where *i* >= 1, and relative to the first symbol of the slot where sub-slot *n+i*-1 is contained.
	+ Nokia/NSB [8]
		- For SR and P/SP-CSI, the starting symbol index within the slot of the related PUCCH config defines the start of the repetition bundle (i.e., the starting PUCCH sub-slot) as well as the starting symbol with respect to that sub-slot boundary

**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 if FH between sub-slot PUCCH repetitions is supported:** Intel [17]
	+ *Moderator comment: Only for 2OS sub-slot based PUCCH or also 7OS!?*
* **No – no need for special handling:** Ericsson [2], Nokia/NSB [8]

**Agree (or conclude) to adopt the following decisions from Cov. Enh. WI for slot based PUCCH repetition also for sub-slot based PUCCH repetition:** Nokia/NSB [8]

* *For a PUCCH resource, if both a new repetition parameter corresponding to Rel-17 dynamic PUCCH repetition factor indication and the Rel-15/16 nrofSlots are configured, the new repetition parameter overrides nrofSlots:* Nokia/NSB [8], Xiaomi [14]
* *In Rel-17, reuse the Rel-16 PUCCH repetition factors 2, 4, 8*: Nokia/NSB [8] – **No:** *support 2,4,6,7,8*: Intel [17]
* *Dynamic PUCCH repetition factor indication for SR or P/SP-CSI on PUCCH is not supported in Rel-17:* Nokia/NSB [8], Xiaomi [14] – **No:** *support at least SR for sub-slot based PUCCH*: Intel [17]

**Support** ***inter-slotFrequencyHopping* for PUCCH repetition operation of PUCCH Format 0 and Format 2.**

* **Yes:** Nokia/NSB [8], Intel [17] (but requires transition period handling at least for 2OS sub-slot based PUCCH config)
* **No:** Intel [17] (if no transition period handling is supported)

**Support dynamic switching between slot and sub-slot based PUCCH repetition**

* No: DoCoMo [18]

**Other suggested enhancements of PUCCH repetition procedure:**

* Drop a PUCCH repetition overlapping with a high-priority DG PUSCH to prevent high-priority UL-SCH data dropping: Nokia/NSB [8]
* Enable multiplexing of HARQ-ACK & SR (at least for PUCCH of priority index 1) to reduce SR latency: Nokia/NSB [8]
* If multiplexing of a repeated PUCCH on PUSCH is supported, the number of REs for UCI carrying HARQ-ACK on PUSCH is scaled with the number of PUCCH repetitions overlapped with a PUSCH: Intel [17]
* Reducing the priority of a repetition according to the number of repetitions that have already been transmitted: Sony [19]
	1. 1st Round of email discussions

**Supported UCI types for sub-slot based PUCCH repetition using using *nrofSlots:***

Looking at the input given on the support of CSI & SR repetition for sub-slot based PUCCH using *nrofSlots*, there are split views (5 supporting, 2 not supporting):

* **Yes**: ZTE [3], vivo [5], Nokia/NSB [8], CATT [9], Samsung [15]
* **No – only for HARQ-ACK**: Ericsson [2], DoCoMo [18]

The moderator has the feeling that sufficient discussions have been carried out (especially during RAN1#106-e) and some companies provided their views on how this can be supported in the specifications considering that the starting symbols index for SR and CSI is not relative to the sub-slot but the slot boundaries.

Let’s see if we can go with majority view here:

**Proposal 4.1: To align with Rel-16 slot-based PUCCH repetition operation, support sub-slot based PUCCH repetition configured with / using *nrofSlots* (i.e., not using dynamic indication) of all UCI types (incl. HARQ, SR & CSI).**

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| --- | --- |
| Supporting companies | Nokia/NSB, QC, Samsung, Panasonic, CATT, vivo, ZTE Huawei/Hisi, DOCOMO (with clarification proposed by Nokia)… |
| Objecting companies |  |

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| --- | --- |
| *Company* | *Comments*  |
| Nokia/NSB | As discussed in our contribution, we think this should be supported and can be supported. Just some clarifications on the starting symbol index and starting PUCCH sub-slot will be needed: * **For SR and P/SP-CSI, the starting symbol index within the slot of the related PUCCH config defines the start of the repetition bundle (i.e. the starting PUCCH sub-slot) as well as the starting symbol with respect to that sub-slot boundary.**
 |
| Samsung | Support in principle. We do not see a reason/need for introducing sub-slot terminology for SR/P-CSI transmissions.  |
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**Decisions from RAN1#106-e from Cov. Enh. WI:**

The Cov. Enh. WI has made the following decisions with respect to dynamic PUCCH indication of slot-based PUCCH repetition operation:

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| --- |
| Agreement * for a PUCCH resource, if both a new repetition parameter corresponding to Rel-17 dynamic PUCCH repetition factor indication and the Rel-15/16 nrofSlots are configured, the new repetition parameter overrides nrofSlots.

Agreement* In Rel-17, reuse the Rel-16 PUCCH repetition factors 2, 4, 8.
* Do not support PUCCH repetition factor larger than 8 In Rel-17.

AgreementDynamic PUCCH repetition factor indication for SR or P/SP-CSI on PUCCH is not supported in Rel-17. |

**Let’ see if we can apply these also directly to sub-slot based PUCCH**:

* Please provide your company name in the tables below
* There is a single comments table for all of these below the 3 proposals.

**Proposal 4.2.1: For sub-slot based PUCCH repetition, the following agreement from Cov. Enh. WI for slot-based PUCCH repetition is adopted also for sub-slot based PUCCH repetition:**

***Agreement***

* ***for a PUCCH resource, if both a new repetition parameter corresponding to Rel-17 dynamic PUCCH repetition factor indication and the Rel-15/16 nrofSlots are configured, the new repetition parameter overrides nrofSlots.***

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, Xiaomi, Intel, QC, Samsung, Panasonic, Sony, CATT, vivo, LG, ZTE Huawei/Hisi, DOCOMO, China Telecom… |
| Objecting companies |  |

**Proposal 4.2.2: For sub-slot based PUCCH repetition, the following agreement from Cov. Enh. WI for slot-based PUCCH repetition is adopted also for sub-slot based PUCCH repetition:**

***Agreement***

* ***In Rel-17, reuse the Rel-16 PUCCH repetition factors 2, 4, 8.***
* ***Do not support PUCCH repetition factor larger than 8 In Rel-17.***

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| Supporting companies | Nokia/NSB, QC, Samsung, Panasonic, Sony, CATT, vivo, LG, ZTE Huawei/Hisi, DOCOMO, China Telecom… |
| Objecting companies | Intel |

**Proposal 4.2.3: For sub-slot based PUCCH repetition, the following agreement from Cov. Enh. WI for slot-based PUCCH repetition is adopted also for sub-slot based PUCCH repetition:**

***Agreement: Dynamic PUCCH repetition factor indication for SR or P/SP-CSI on PUCCH is not supported in Rel-17.***

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| Supporting companies | Nokia/NSB, Xiaomi, Intel, QC, Samsung, Panasonic, Sony, CATT, vivo, LG, ZTE Huawei/Hisi, DOCOMO, China Telecom… |
| Objecting companies |  |

If you have any additional comments on these 3 proposals to adopt the agreed behavior from Cov. Enh. WI for slot-based PUCCH also for sub-slot based PUCCH, please provide them below:

|  |  |
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| *Company* | *Comments on Proposals 4.2.1 to 4.2.3*  |
| Intel | On P 4.2.2, in our tdoc we suggested to also consider repetition factors 7 and 6 which result in a full slot length for 2-symbol sub-slot repetitions for NCP and ECP respectively. |
| Moderator | @Intel: please note that the PUCCH repetition may not start in the first sub-slot of a slot and a PUCCH repetition bundle may cross the slot-boundary. Therefore, there seems to be no need to optimize for this case specifically!? |
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**Inter-slot FH for short PUCCH formats 0 and 2:**

In Rel-16, inter-slot FH for all PUCCH formats that support PUCCH repetition (i.e., 1, 3 & 4) are supported. The question here now would be, if we support the inter-slot (or for sub-slot based PUCCH inter-subslot) FH also for the short PUCCH formats 0 & 2. The moderator thinks that this should be also discussed early as this may have an effect on how we especially enable the configuration of PUCCH repetition of format 0 (i.e., using a single new RRC parameter or using the structure used to configure it for formats 1,2,3,4 in Rel-16 RRC specs.

Please note, that Intel raised the point of transient gaps for 2OS sub-slot based PUCCH configuration in terms of transient gaps and suggests preventing inter-slot FH for short PUCCH slot lengths. Therefore, the moderator splits the questions to have separate input on the support for 7OS sub-slot & slot-based PUCCH repetition and 2OS sub-slot based PUCCH repetition (where the transient gap issue is prominent), accordingly.

**Proposal 4.2.4: Support** ***inter-slotFrequencyHopping* for PUCCH repetition operation of PUCCH Format 0 and Format 2 at least for slot-based PUCCH configurations and 7-OS sub-slot based PUCCH configurations.**

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| Supporting companies | Nokia/NSB, Intel, QC (with separate UE capability signaling), Samsung, Panasonic, Sony, CATT, vivo, DOCOMO… |
| Objecting companies |  |

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| *Company* | *Comments*  |
| Nokia/NSB | We see in principle no reason to not support this (to improve reliability) |
| Intel | We are OK to split discussion into ‘short’ and ‘long’ sub-slots, and don’t see the issue for long ones. |
| Samsung | We do not see any relevance between the length of a PUCCH repetition and whether or not a gap is needed for frequency hopping. |
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**Proposal 4.2.5: Support** ***inter-slotFrequencyHopping* for PUCCH repetition operation of PUCCH Format 0 and Format 2 also for 2-OS sub-slot based PUCCH configuration.**

* ***Note: this may lead to transient gap issues***

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| Supporting companies | Nokia/NSB, QC (with separate UE capability signaling), Samsung, Panasonic, Sony, CATT, vivo, DOCOMO |
| Objecting companies | Intel |

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| *Company* | *Comments*  |
| Nokia/NSB | For this case, the advantates are less clear but we would like to not here, that for smaller SCS the effect of the transient periods is negligible (and the configuration is anyhow under gNB control / gNB can manage) |
| Intel | Since RAN1 does not introduce specific handling on transient gaps, the only solution we see is to restrict the complicated cases from applying FH. |
| Samsung | Similar operations are supported in LTE sTTI (PUCCH hopping between symbols in 2/3 symbols) and NR PUSCH intra-slot FH hopping. We do not see any relevance between the length of a PUCCH repetition and whether or not a gap is needed for frequency hopping. If there is any issue, that may be for very large SCS such as the ones considered in Beyong 52.6 GHz and discussion can happen there. |
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# 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:

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| 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 (6): TDRA pruning/grouping per DL slot after TDRA determination per sub-slot.**
	+ **Support:** Huawei/HiSi [1], ZTE [3], Nokia/NSB [8], CATT [9], Samsung [15], Intel [17]
* **Option 2 (2): TDRA pruning/grouping per ‘DL’ sub-slot after TDRA determination per sub-slot.**
	+ **Support:** NEC [7], Qualcomm [27]

**Further provided details on the procedure:**

* Huawei/HiSi [1]
	+ ***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 may be potentially 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.*

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| …*/\*----------------Step 1: Determine DL slots consisting of DL sub-slots associated to the determined UL sub-slot--------------\*/*If the UE is provided *subslotLengthForPUCCH*while  $K\_{1,k}^{subslot}=K\_{1,k}$ // $K\_{1}^{subslot}$ is introduced to contain the original sub-slot based K1 valuesModify $K\_{1,k}$ as the smallest integer that satisfies $N\_{U}^{subslot}-K\_{1,k}^{subslot}+n\_{slot}^{subslot}×K\_{1,k}>0$, where  is the *k*-th value in set  representing the slot level timing, $N\_{U}^{subslot}$ is the relative index of subslot $n\_{U}$ within the slot, and $n\_{slot}^{subslot}$ is the number of subslots in per slot, calculated by 1*4 /* $l\_{subslot}$*, where* $l\_{subslot}$ *is configured by subslotLengthForPUCCH.* // $K\_{1,k}$ is modified as the slot based K1 values, and set  is accordingly modified as the set of slot based K1 values;end whileend ifDelete duplicated elements in $K\_{1}$*/\*--------------------------------------------------------------End of Step 1--------------------------------------------------------------------\*/*while  if  Set  – index of a DL slot within an UL slotwhile  Set  to the set of rowsSet  to the cardinality of Set  – index of row in set if slot  starts at a same time as or after a slot for an active DL BWP change on serving cell  or an active UL BWP change on the PCell and slot  is before the slot for the active DL BWP change on serving cell  or the active UL BWP change on the PCell $n\_{D}=n\_{D}+1$; else */\*----------------------------------------------------------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. Determine DL slots consisting of DL sub-slots associated to the determined UL sub-slot-------------------------------------------------------------------\*/*while if the UE is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot from slot $\left⌊\left(n\_{U}-K\_{1,k}\right)⋅2^{μ\_{DL}-μ\_{UL}}\right⌋+n\_{D}-N\_{PDSCH}^{repeat,max}+1$ to slot $\left⌊\left(n\_{U}-K\_{1,k}\right)⋅2^{μ\_{DL}-μ\_{UL}}\right⌋+n\_{D}$, at least one symbol of the PDSCH time resource derived by row  is configured as ULwhere  is the *k*-th slot timing value in set , or, if the UE is provided *subslotLengthForPUCCH*, and the end symbol of the PDSCH time resource derived by row  overlaps with a DL sub-slot which is not associated with  according to any timing value of $K\_{1,i}^{subslot},i=1,…∁(K\_{1}^{subslot})$ in timing set $K\_{1}^{subslot}$,;else*/\*-------------------------------------------------------------End of Step 2-----------------------------------------------------------------\*/*end ifend while…end ifend whileend if;end while… |

* Ericsson [2]
	+ 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 $\left⌊2^{μ\_{DL}-μ\_{UL}}/N\right⌋$, where N is the number of sub-slots in an UL slot.
	+ Example pseudo code for pruning/grouping per DL slot presented:

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| For the set of slot timing values, the UE determines a set of  occasions for candidate PDSCH receptions or SPS PDSCH releases according to the following pseudo-code. …Set  - index of occasion for candidate PDSCH reception or SPS PDSCH releaseSet Set Set  to the cardinality of set Set *k* =0 – index of slot timing values , in descending order of the slot timing values, in set  for serving cell Partition symbols of a DL slot into $\left⌈\frac{1}{\frac{\left(2^{μ\_{DL}-μ\_{UL}}\right)}{N} ∙ max⁡(2^{μ\_{UL}-μ\_{DL}},1)}\right⌉$ equally non-overlapped subsets of DL symbols, indexed by $l=0,1,…,\left⌈\frac{1}{\frac{\left(2^{μ\_{DL}-μ\_{UL}}\right)}{N} ∙ max⁡(2^{μ\_{UL}-μ\_{DL}},1)}\right⌉-1.$ Then partition the set $R$ into $\left⌈\frac{1}{\frac{\left(2^{μ\_{DL}-μ\_{UL}}\right)}{N} ∙ max⁡(2^{μ\_{UL}-μ\_{DL}},1)}\right⌉$ subsets $R\_{l}$ where $ l=0, 1,…, \left⌈\frac{1}{\frac{\left(2^{μ\_{DL}-μ\_{UL}}\right)}{N} ∙ max⁡(2^{μ\_{UL}-μ\_{DL}},1)}\right⌉-1$, where each subset $R\_{l}$ contains TDRA entries with SLIV ending within the corresponding subset of DL symbols.Set $l^{\*}=0$ If a UE is not provided *ca-SlotOffset* for any serving cell of PDSCH receptions and for the serving cell of corresponding PUCCH transmission with HARQ-ACK informationwhile  if  Set  – index of a DL slot within an UL slotwhile $n\_{D}<max\left(\left⌊\left(2^{μ\_{DL}-μ\_{UL}}\right)/N\right⌋,1\right) $ Set  to ~~the set of rows~~ the subset $R\_{l\*}$Set  to the cardinality of Set  – index of row in set if slot  starts at a same time as or after a slot for an active DL BWP change on serving cell  or an active UL BWP change on the PCell and slot $\left⌊\left(n\_{U}-K\_{1,k}\right)⋅\left(2^{μ\_{DL}-μ\_{UL}}\right)/N\right⌋+n\_{D}$ is before the slot for the active DL BWP change on serving cell  or the active UL BWP change on the PCell $n\_{D}=n\_{D}+1$; else while if the UE is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot from slot $\left⌊\left(n\_{U}-K\_{1,k}\right)⋅\left(2^{μ\_{DL}-μ\_{UL}}\right)/N\right⌋+n\_{D}-N\_{PDSCH}^{repeat,max}+1$ to slot $\left⌊\left(n\_{U}-K\_{1,k}\right)⋅\left(2^{μ\_{DL}-μ\_{UL}}\right)/N\right⌋+n\_{D}$, at least one symbol of the PDSCH time resource derived by row  is configured as ULwhere  is the *k*-th slot timing value in set , …else… end ifend while…end ifend whileend if;$l^{\*}=l^{\*}+1$; end while…end if |

* ZTE [3]
	+ *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.*

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| 9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel...while if the UE is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot from slot $\left⌊\left(n\_{U}-K\_{1,k}\right)⋅2^{μ\_{DL}-μ\_{UL}}\right⌋+n\_{D}-N\_{PDSCH}^{repeat,max}+1$ to slot $\left⌊\left(n\_{U}-K\_{1,k}\right)⋅2^{μ\_{DL}-μ\_{UL}}\right⌋+n\_{D}$, at least one symbol of the PDSCH time resource derived by row  is configured as ULwhere  is the *k*-th slot timing value in set ,Or, if the UE is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot from slot  to slot , the end symbol of the PDSCH time resource derived by row  does not overlap with any UL slot(s) for an associated PUCCH transmission,where  is the *k*-th slot timing value in set , where the UL slot(s) simultaneously meets: 1) the UL slot(s) overlaps with the aforementioned each slot in the time domain; 2) the UL slot(s) belong to a set of slots determined by  where  is the each k1 value in set ,;else; end if...while if the UE is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot from slot $\left⌊\left(n\_{U}-K\_{1,k}\right)∙2^{μ\_{DL}-μ\_{UL}}\right⌋+\left⌊\left(\frac{N\_{slot,offset}^{UL}}{2^{μ\_{offset,UL}}}-\frac{N\_{slot,offset,c}^{DL}}{2^{μ\_{offset,DL,c}}}\right)∙2^{μ\_{DL}}\right⌋+n\_{D}-N\_{PDSCH}^{repeat,max}+1$ to slot $\left⌊\left(n\_{U}-K\_{1,k}\right)∙2^{μ\_{DL}-μ\_{UL}}\right⌋+\left⌊\left(\frac{N\_{slot,offset}^{UL}}{2^{μ\_{offset,UL}}}-\frac{N\_{slot,offset,c}^{DL}}{2^{μ\_{offset,DL,c}}}\right)∙2^{μ\_{DL}}\right⌋+n\_{D}$, at least one symbol of the PDSCH time resource derived by row  is configured as ULwhere  is the *k*-th slot timing value in set , Or, if the UE is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot from slot  to slot , the end symbol of the PDSCH time resource derived by row  does not overlap with any UL slot(s) for an associated PUCCH transmission,where  is the *k*-th slot timing value in set , where the UL slot(s) simultaneously meets: 1) the UL slot(s) overlaps with the aforementioned each slot in the time domain; 2) the UL slot(s) belong to a set of slots determined by  where  is each k1 value in the set ,;else; end if... |

* NEC [7]
	+ *PDSCH TDRA grouping per DL sub-slot: This solution can be achieved by splitting a TDRA table into N TDRA sub-tables based on the sub-slot length and virtual DL sub-slot, N is the number of sub-slots within a slot. Then do pruning based on TDD configuration and sub-table per sub-slot similar as Rel-15. It is obvious that the Type-1 HARQ-ACK codebook construction based on PDSCH TDRA grouping per DL sub-slot can follow current slot based Type-1 HARQ-ACK codebook construction mechanism, regardless of whether the numerology configuration for DL and UL is the same or different. Which is achieved by replacing the DL slot, the UL slot and TDRA table with the virtual DL sub-slot, the UL sub-slot and the corresponding sub-TDRA table, the corresponding pseudo code is shown in the appendix.*
	+ *PDSCH TDRA grouping per DL slot: One candidate proposal is to replace* $2^{μ\_{DL}-μ\_{UL}}$ *by* $ceil\left(2^{μ\_{DL}-μ\_{UL}}/N\right)$ *and replace* $2^{μ\_{UL}-μ\_{DL}}$ *by* $ceil\left(N×2^{μ\_{UL}-μ\_{DL}}\right) $ *in the current pseudo code for slot based Type-1 HARQ-ACK codebook construction, where N is the number of sub-slots in an UL slot. Then do pruning based on TDD configuration and the TDRA table per DL slot similar as Rel-15. However, it will also lead to some redundant HARQ-ACK bits when the value* $2^{μ\_{DL}-μ\_{UL}}/N$ *is not an integer. If combined with another proposal to remove the SLIVs from the TDRA table that is not associated with the UL sub-slot, i.e., a HARQ-ACK multiplexing window for the UL sub-slot is determined based on the configured K1 set, the SLIVs ending not in the window will be removed, then the redundancy will be eliminated.*
* Nokia/NSB [8]
	+ *This operation is logically nicely captured by the steps described by Huawei/HiSi [1] and ZTE [3].*
* Intel [17]:
	+ For TDRA determination, reuse the existing pseudo-code structure and add number of sub-slot $N\_{sub}$ into existing equations. For example, small revision for ‘while’ sentence. while  -> to replace $2^{μ\_{DL}-μ\_{UL}}$ with $floor(\frac{2^{μ\_{DL}-μ\_{UL}}}{N\_{sub}})$ . And revision for ‘if’ sentence may be needed, “if ” -> replace $2^{μ\_{UL}-μ\_{DL}}$ with $floor(N\_{sub}\*2^{μ\_{UL}-μ\_{DL}})$, or $ceil(N\_{sub}\*2^{μ\_{UL}-μ\_{DL}})$.
* Qualcomm [27] – for sub-slot based grouping/Pruning:
	+ *for each UL sub-slot* $n\_{U}-K\_{1,k}$*, UE determines a set of TDRA candidates that ends in the UL sub-slot, and perform TDRA pruning within the group based on the Rel-15 approach.*
	+ A TP to support the subslot based TDRA grouping and Type-1 HARQ-ACK reporting can be found in our previous RAN1 contribution R1-2008608

**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 [7]
	1. 1st round of email discussions

Looking at the input given on the ‘DL slot’ versus ‘sub-slot’ based TDRA grouping/pruning after TDRA / PDSCH allocation determination per PUCCH sub-slot, the views are still diverse (in RAN1#106-e: 13 vs. 2, in RAN1#106bis-e input documents: 6 vs. 2:

* **Option 1 (6): TDRA pruning/grouping per DL slot after TDRA determination per sub-slot.**
	+ **Support:** Huawei/HiSi [1], ZTE [3], Nokia/NSB [8], CATT [9], Samsung [15], Intel [17]
* **Option 2 (2): TDRA pruning/grouping per ‘DL’ sub-slot after TDRA determination per sub-slot.**
	+ **Support:** NEC [7], Qualcomm [27]

The arguments of why to support one way or the other seem to have not really changed with both camps highlighting certain similarities with the existing code.

Let’s see if we can go with majority view here. Therefore, the following proposal based on majority is brought forward:

**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 sub-slot.**

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| Supporting companies | Nokia/NSB, Intel, Samsung, Sony, CATT , vivo,TCL, ZTE Huawei/Hisi, DOCOMO… |
| Objecting companies | Qualcomm |

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| *Company* | *Comments*  |
| Qualcomm | Thanks HW/ Ericsson/ ZTE for providing TPs for Option 1. However, in our view, none of these TPs are complete.1. For the HW TP, the idea is to create a new set of K1 values, referred to as K1^subslot, to represent the set of subslot K1 times, and re-intepret the K1 set in the R-15 pesudo code as slot-based K1. This works OK for the case in which UL and DL has the same numerology. **However it has problems when the UL and DL has different numerology.** The problem is that, the proposal of Option 1 is to do TDRA prunning per DL slot, but the pesudo code has an outer-while loop that is defined per UL slot. To explain the problem, consider the following scenario: here, the PDSCH cell has 15K SCS, and the PUCCH cell has 30KHz SCS. In addition, the PUCCH cell is configured with subslotlength=7, I.e., 1 UL slot=2 UL subslots. Consider a PDSCH that ends in the second subslot of UL slot 2n+2. For this PDSCH, the HARQ-ACK can not be transmitted on any of the two subslots in UL slot 2n+3, since the condition mod(n\_U-k1+1, 2)=0 is not satisfied for these UL subslots. Thus, the earliest UL subslot that the UE can transmits the HARQ-ACK for this PDSCH is in the first subslot of UL slot 2n+4. This incurs a latency of 0.5 ms compared to Option 2 (where the UE can already feedback HARQ-ACK in the first UL subslot of UL slot 2n+3).

Also, the HW TP requires the UE to perform two extra steps compared to Option 2: 1) a pre-processing step to determine the set K1 of slot-based K1 timings to run the pesudo code; and 2) for each DL/UL slot, the **UE effectively need to run a loop over the set of UL subslots** overlapping with that UL/DL slots, and determine whether that TDRA needs to be pruned or not. This increases the UE/gNB implementation complexity.1. The problem with E///’s TP is well explained in NEC’s contribution, as cited above from the FL.
2. For ZTE’s TP, it is unclear to us whether the unit of k1 is slot (UL? Or DL?) or subslot. If it’s slot-based, then it clearly contradicts with previous agreements that K1 should be intepreted in the unit of subslot. If the pesudo code is subslot based, we don’t see how the TDRA prunning is performed per DL slot. In addition, it seems that in ZTE’s TP a pre determination step before the while loop is also needed, as in HW’s TP. Could the proponent clarify?

Overall, we still prefer Option 2, which is much simpler, and has lower latency compared to Option 1 (in view of HW’s TP for Option 1) in the mixed numerology scenario.  |
| ZTE | We have agreed that sub-slot based Type-1 codebook should be specified. And the proposal 5.1 is actually a small issue only about the whether the TDRA pruning/grouping is performed per DL slot or per ‘DL’ sub-slot. We need move forward. Actually we have no such term of ‘DL’ sub-slot. If we want to define the term of ‘DL’ sub-slot, it will cause more specification effort.We can’t gurantee the possible TP in the contribution is complete, it is just a reference. The final TP should be based on the editor output. Now we just only to agree an option about how to pruning/grouping.To echo Qualcomm’s two questions. The unit of k1 is absolutely based on the UL sub-slot which aligns the previous agreement. The TDRA prunning performing per DL slot has no explicitly change in specification as the legacy TDRA pruning is already based on per DL slot. In the second green highlight part of our possible TP, all the possible allowed PDSCHs in one slot are gathering together for pruning. Next question, for pre determination step before the while loop, it is intended to avoid 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, more details can refer issue 1 in our contribution. Simply or not accurately say, it prevents the DL slot entering the loop multiple times which is unnecessary. It should be noted that this procedure is also valid for per ‘DL’ sub slot as the issue is common for both of options. |
| Huawei/Hisi | To QC: The TP provided by companies is to show the example of the potential impact to the specification. The condition of mod(n\_U-k1+1, 2)=0 would anyway be modified as per the agreement of the 106-e meeting, regardless it is for slot-based TDRA grouping or subslot based TDRA grouping, since the definition of k=0 is different from that of R15.

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| **Agreement**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. |

For the complexity issue, for both slot based TDRA grouping and subslot based TDRA grouping, it targets on a specific UL sub-slot and go through the associated DL slots/subslots, so we do not see a specific complexity issue on point 2). Again, regarding the 106 agreement, both schemes needs changes on the R15 pseudo code, so the additional complexity of slot based TDRA grouping scheme is marginal.At the end, the issue of subslot-based TDRA grouping is the large redundant HARQ-ACK payload (up to **75%** higher than slot based grouping). If such redundancy is not reduced, the massive payload of Type 1 CB will significantly weaken the reliability of the UCI. |
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# 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.**Agreement**Update the following RAN1#105-e agreement as (RED): * 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

**Agreement**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

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

* 1. Summary of companies input in their contributions

**SUL – PUCCH carrier vs. cell switching:**

* **Support all cases (1, 2-1, 2-2, 3) (5 companies):** Huawei / HiSi [1], vivo [5], CATT [9], China Telecom [10], Mediatek [16],
	+ If only 2 PUCCH cells / carriers supported, case 2-2 cannot be supported: CATT [9]
* **Prioritize the feature completion for case 1 & case 2-1 (5 companies):** Ericsson [2], Nokia/NSB [8], Samsung [15], DoCoMo [18], LGE [25]
	+ Discussions for case 2-2 and/or case 3 should be deprioritzed: Ericsson [2]
	+ Discuss the support after having the baseline feature design completed: Nokia/ NSB [8]
	+ Consider support for PUCCH carrier switching to include NUL/SUL after progressing the specifications for PUCCH cell switching and subject to minimum specification impact: Samsung [15]
	+ RAN1 should complete the design of PUCCH carrier switching for Case 1 and Case 2-1 without relying on the outcome of discussion whether and/or how Case 2-2 and Case 3 are supported: DoCoMo [18]
	+ Prioritize Case 1 and 2-1 and deprioritize (or do not pursue) Case 2-2 for PUCCH carrier switching: LGE [25]
* **Only support case 1 & case 2-1 (do NOT support cases 2-2 and Case 3) (1 company)**: Qualcomm {27]
	+ If cases 2-2 and case 3 are not supported, PUCCH switching should be limited to TDD carriers only: Huawei / HiSi [1], vivo [5]
	+ Qualcomm [27] reasons:
		- “Firstly, in our view, any UL CA cases that involve at least one FDD UL, the feature of PUCCH carrier switching doesn’t need to be supported. The reason is that in this case, there is always PUCCH available on one carrier (namely on the FDD carrier), so switching away from that carrier for the purposes of latency reduction is pointless.”
		- “Secondly, power control for carrier switch between SUL and NUL does not work, due to SUL does not have paired DL carrier hence lack of DL path loss measurement. Consider a case where PUCCH is switch from NUL to SUL, due to no DL path loss measurement is available, open loop power control for PUCCH transmission does not work.”
* **Only support case 1, case 2-1 & case 3 (do NOT support case 2-2) (1 company)**: ITRI [28]
	+ “Regarding to the case 2-2, we don’t think it is a common use case for the system deployment”

**Generic for PUCCH carrier switching:**

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

* 2 (PCell & 1 SCell, 1+1): vivo [5], CAICT [12], Samsung [15], Apple [26]
* 4 (in total, 3+1): ZTE [3], Nokia/NSB [8] (based on UE capability), CMCC [11] (for dynamic DCI indication), Panasonic [21] (UE capability indication if 2 or 4 are supported by UE),
* Based on UE capability indication: FGI/APT [22]
* No limitation for semi-static time domain pattern: CMCC [11]
* Up to maximum number of configured serving cells: ETRI [20], FGI/APT [22] (i.e., no limitation)

**TPC operation for PUCCH cells:**

* Support independent TPC per PUCCH cell and the related RAN1#106-e Mod. Proposal 6.1: Huawei/HiSi [1] (with changes cell  carrier), vivo [5], Nokia/NSB [8], CAICT [12], Samsung [15], Mediatek [16], Qualcomm [27] (?)

**PUCCH spatial relation update:**

* Support to use MAC-CE to signal PUCCH spatial relation on Scell(s) with PUCCH carrier switch: FGI/APT [22], Qualcomm [27]

**Misaligned PUCCH configuration on different PUCCH cells:**

* for example, sub-slot configuration, priority indication of PUCCH, SPS PDSCH only HARQ-ACK, and PUCCH repetition: FGI/APT [22]
	+ To handle misaligned PUCCH configuration, consider prohibiting some parameters in PUCCH-Config from being different or establishing some rules for PUCCH carrier switching

**New PHR type for PUCCH cell switching:** Qualcomm [27] (type 4 PHR for PUCCH cell switching and simultaneous PUSCH/PUCCH – no details on what ‘type 4’ is are given)

**Other:**

* Study and decide if /how to support joint operation of PUCCH carrier switch, parallel PUCCH/PUSCH transmission, and intra-UE multiplexing (i.e., interaction with AI 8.3.3 features): Qualcomm [27]

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

**Carrier indication:**

* **Support RAN1#106** *Modified Proposal 6.2* **of new, dedicated DCI field:** Huawei/HiSi [1] (with change cell  carrier), Ericsson [2], vivo [5], Nokia/NSB [8], CAICT [12], Samsung [15], Mediatek [16]
	+ Further details:
		- DCI field size determined based on the size of the carrier set / list: Ericsson [2] (largest set among PUCCH cell groups),
		- Limited to 1bit: Samsung [15] (for DCI format 1\_0, 1bit from RV or HPN field could be used)
* **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 [3], Intel [17], Panasonic [21], LGE [25]
	+ PRI field size can be extended: Panasonic [21], – No / questionable: LGE [25]
* Use SUL/UL field in UL grant (i.e., DCI formats 0\_1 / 0\_2): Xiaomi [14]

**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 (‘stable’ RAN1#106-e Mod. Proposal 6.3)**

* **Support:** Ericsson [2], vivo [5], Nokia/NSB [8], CAICT [12], Interdigital [23]

**Applicability of dynamic PUCCH cell indication:**

In addition to the RAN1#106-e agreement, the dynamic PUCCH cell indication also applies to:

* SPS HARQ without associated PDCCH / DCI based on the activation: vivo [5], Nokia/NSB [8]
	+ For SPS, the carrier indication is considered ‘dynamic’ only for the first HARQ-ACK, i.e., the carrier indication in the activation DCI, when applied for later SPS HARQ-ACKs, does not force to indicate the same cell/carrier for HARQ-ACK of dynamically scheduled PDSCH to the slots with SPS HARQ-ACK: Nokia/NSB [8]
* Scell dormancy indication: Nokia/NSB [8], ASUSTek [29] (without scheduling PDSCH)
* Rel-17 beam indication DCI for unified TCI without scheduling PDSCH: ASUSTek [29]

**DCI format 1\_2 support:**

* Yes: Nokia/NSB [8] (for DCI format 1\_2, separate bit-width configuration)

**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):** Ericsson [2], vivo [5], NEC [7], CATT [9], Intel [17] (at least if semi-static time domain pattern is not configured),
	+ **Alt. 1 PUCCH resources should be overlapping:** Ericsson [2], vivo [5] (?)
	+ **Alt. 2 PUCCH slots overlapping, PUCCH resources do not need to be overlapping:** Nokia/NSB [8], CATT [9],
	+ **Additional details:**
		- Exception is SPS-HARQ together with CSI: Ericsson [2]
* Multiplexing procedures for PUCCH transmissions on P(S)Cell and PUCCH SCell are not supported: Samsung [15] (aim for minimum specs impact)

**Mixed numerology / sub-slot length operation:**

* **PCell PUCCH slot length LONGER than PUCCH slot length at dynamically indicated cell**
	+ New Alt. 3: UE expects that for supporting dynamic PUCCH carrier switching, PUCCH (including CSI, SR, HARQ-ACK, etc.) is always transmitted on one carrier at the duration of PCell slot: ZTE [3]
	+ multiplex on the first overlapping dynamically indicated PUCCH cell slot: Nokia/NSB [8], TCL [13] (more than one can be indicated)
	+ UE does not expect multiple HARQ-ACK slots on the same indicated PUCCH cell or different PUCCH cells: DoCoMo [18]
* **PCell PUCCH slot length SHORTER than PUCCH slot length at dynamically indicated cell**
	+ New Alt. 3: UE expects that for supporting dynamic PUCCH carrier switching, PUCCH (including CSI, SR, HARQ-ACK, etc.) is always transmitted on one carrier at the duration of indicated PUCCH cell slot: ZTE [3]
	+ the UE does not expect the same UCI type (i.e., HARQ-ACK, SR or CSI) from more than one PCell PUCCH slot to be overlapping with a single dynamically indicated PUCCH cell slot: Nokia/NSB [8], TCL [13] (UCI in general), DoCoMo [18] (HARQ-ACK)

**Supported UCI types (in addition to HARQ-ACK):**

* **Limited to SR and SPS-HARQ only (no CSI):** Nokia/NSB [8], Intel [17] (SR when multiplexed with HARQ)
* **Drop CSI & SR:** CATT [9]
	+ For the case of different numerologies, the slot based the smallest SCS is used as the reference slot: CATT [9]

**DCI size alignment with PUCCH cell specific PUCCH config:**

* China Telecom [10]: if the bit width of the PDSCH-to-HARQ\_feedback timing indicator in DCI format 1\_1 or 1\_2, or the bit width of the PUCCH resource indicator in DCI format 1\_2 for one PUCCH carrier is not equal to the same field for another PUCCH carrier, a number of most significant bits with value set to '0' are inserted to smaller field until the bit width of the field for all the PUCCH carrier are the same

**HARQ codebook construction:**

* **For Type 1 CB**,
	+ FFS Type 1 CB construction: NEC [7]
	+ the UE is not expected to be configured with non-aligned PUCCH slots and different k1 sets across all PUCCH candidate cells: Nokia/NSB [8]
	+ consider overlapped slots in other cells which includes SPS HARQ-ACK (or PDSCH scheduled by DCI format 1\_0) when constructing the HARQ-ACK codebook in the target PUCCH cell: CAICT [12], DoCoMo [18] (union of the PDSCH / TDRA set of PCell and dynamically indicated PUCCH cell, for the dynamically indicated PUCCH cell only the k1 set(s) configured for the DCI formats with carrier switching)
* **For Type 2 CB**,
	+ the Rel-16 mechanism for HARQ-ACK codebook construction can be re-used considered the overall HARQ payload size at the PUCCH target cell slot (incl. DAI): Nokia/NSB [8], DoCoMo [18]
	+ consider overlapped slots in other cells which includes SPS HARQ-ACK when constructs HARQ-ACK codebook in the target PUCCH cell: CAICT [12]

**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 [26], Xiaomi [14]
* Out-of-order triggering is not supported: Xiaomi [14]

**Other:**

* Support for scheduled PUCCH: Mediatek [16]
* Nested PUCCH symbols across CCs are not allowed for PUCCH carrier switching: Apple [26]

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

**Time domain pattern configuration:**

* **Support RAN1#106 *Mod3 Proposal 6.4* on the time domain pattern configuration:** Huawei / HiSi [1] (with change cell  carrier), vivo [5], Nokia/NSB [8], CAICT [12], Mediatek [16] (?, unit is one slot)
* **Support configurable periodicity of the time-domain pattern (RAN1#106-e *Proposal 6.8.2*):** ZTE [3], vivo [5],
* **10ms periodicity always (for simplicity):** CMCC [11], CAICT [12],
* **Pattern length & periodicity given by TDD-UL-DL-pattern:**  FGI/APT [22] (assuming a single pattern)

**Reference numerology / cell:**

* **PCell / PSCell / PUCCH-SCell is reference cell (5):** Huawei/HiSi [1] (NUL of PCell), Ericsson [2], Nokia/NSB [8], DoCoMo [18], Qualcomm [27] (defining pattern numerology and k1 interpretation),
* **Reference cell /carrier configured by RRC (5):** ZTE [3], vivo [5] (reference carrier to have the smallest SCS of PUCCH cells), Mediatek [16], FGI/APT [22], LGE [25]
* **Reference cell is the PUCCH cell with the smallest SCS (6):** CATT [9], China Telecom [10], CAICT [12], Samsung [15] (PCell can be considered, if smaller PCell SCS than SCell is not supported), FGI/APT [22], Apple [26]
* **Reference numerology is the largest SCS (1):** CMCC [11]

**CA slot offset considerations:**

* Regarding the carrier offset case, slot0 is aligned with Pcell/PScell: CMCC [11]
* PCell/PScell defines the reference slot, slot number of Scells is calculated according to *slot offset configuration given by* $N\_{slot, offset}^{CA}$: CMCC [11]

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

* **K1 interpretation on the reference cell to define the PUCCH target cell ( RAN1#106-e Mod. Proposal 6.5) (X):** Huawei/HiSi [1] (with change cell  carrier), ZTE [3], vivo [5], Nokia/NSB [8], China Telecom [10] (PCell, although reference cell may be another cell), CAICT [12], DoCoMo [18], LGE [25], Qualcomm [27] – **NO- k1 based on target PUCCH cell numerology:** Mediatek [16]
* **PRI interpretation on the PUCCH target cell (RAN1#106-e Proposal 6.6) (5):** Huawei / HiSi [1] (with change cell  carrier), ZTE [3], vivo [5], Nokia/NSB [8], CATT [9], CAICT [12]
* **Semi-static PUCCH resource on target cell defined by PUCCH-config for the target cell:** CATT [9]
* **Periodicity/offset for SR/CSI configurations and K1 for SPS HARQ-ACK are interpreted based on the reference cell numerology:** Apple [26]
	+ The PUCCH resource ID for SR/CSI/SPS HARQ-ACK is interpreted based on the PUCCH configuration of the target PUCCH cell

**Mixed numerology handling:**

* **For shorter PUCCH slot length on the target PUCCH cell** (than the reference cell), the PUCCH transmission is in
	+ the first PUCCH slot on the target cell overlapping with the reference cell slot: Huawei/HiSi [1], CATT [9], China Telecom [11], CAICT [12], TCL [13], Samsung [15], DoCoMo [18], LGE [25], Qualcomm [27] (first ‘actual’ slot),
	+ Through some indication: Ericsson [2], ZTE [3], Nokia [8], Panasonic [21]
		- configured slot\_offset pattern to define which overlapping PUCCH slot (i.e. time domain pattern contains ‘cell index’ & ‘slot\_offset’): Ericsson [2], ZTE [3]
		- using k1\_relative within the PCell slot indicated using HARQ-feedback indicator in the DCI: Nokia/NSB [8]
		- configured slot-offset per PUCCH target cell (within overlapping PCell slot): Panasonic [21]
* **For switching to longer PUCCH slot length on the target cell** compared to the reference cell:
	+ gNB implementation takes care of that timelines are met for PUCCH transmission switching to Scell: Nokia/NSB [8]
	+ UE does not expect to be indicated for HARQ-ACK codebooks in more than one of the PCell slots overlapping with a single, determined PUCCH cell slot: Nokia/NSB [8], CATT [9], TCL [13] – **FFS:** DoCoMo [18] (needs to be clarified whether multiplexing is allowed)
	+ This case is not supported: Samsung [15]
	+ ZTE [3] - New Alt. 3: UE does not expect overlapping PUCCH slots with semi-static time domain PUCCH cell indication on more than one carrier, i.e., gNB should only configure a single PUCCH cell for a final PUCCH slot.
		- *Moderator comment:* the proposal does not seem to solve the issue, as this only means there needs to be an unambiguous PUCCH cell determination but not what happens if there is more than one overlapping reference / PCell PUCCH slot!? (.. the proposal seems to be more going towards the RAN1#106-e proposal *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. !?*)

**Alignment of PUCCH switching points with PUCCH slot boundaries:**

* Support RAN1#106-e Proposal 6.5.5 (i.e., PUCCH carrier switching points are to be aligned with PUCCH slot/sub-slot boundaries of a PUCCH cell):ZTE [3] (?)**,** vivo [5], Nokia/NSB [8], CAICT [12], TCL [13],

**PUCCH repetition operation:**

* The target cell is determined for each PUCCH repetition individually: Huawei/HiSi [1]
* PUCCH repetition factor is determined based on the PUCCH resource on the target PUCCH cell after PUCCH carrier switching: DoCoMo [18]
* A PUCCH repetition mapping to a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported: DoCoMo [18] (drop PUCCH repetitions mapped to a different PUCCH cell), Panasonic [21] (mentions same carrier for PUCCH repetition in SPS HARQ-ACK section), ASUSTek [29] (transmitted on the determined carrier for the first PUCCH repetition)
* Changing a serving cell for PUCCH transmission with repetition may have the same numerology between serving cells if supported: ETRI [20]
* Further study: NEC [7], Qualcomm [27]

**HARQ-ACK codebook construction:**

* **Type 1 CB** uses the K1 set(s) configured for the reference cell / numerology: vivo [5], Nokia/NSB [8], CAICT [12]
	+ Same K1 set can be configured for each PUCCH cell: vivo [5]
		- *Moderator comment*: If anyhow the K1 set(s) of the reference cell is/are used, the configuration of the K1 set(s) of the other PUCCH cells would anyhow not be used in the codebook construction. There may be only a different in the joint operation of semi-static & dynamic PUCCH cell indication.
* **Type 2 CB**:
	+ Type 2 HARQ-ACK CB construction (based on the k1 interpretation of the PCell / reference cell) can be directly reused: Nokia/NSB [8]
	+ based on the reference slot and the numerology of reference cell rather than based on the actual slot and numerology of the target PUCCH cell: CAICT [12]

**SFI utilization:**

* Legacy semi-static SFI and dynamic SFI operation applies on the target PUCCH cell: Apple [26]

**SCell deactivation**

* For semi-static PUCCH carrier switch, if a SCell indicated in the time pattern is deactivated by MAC-CE, the SCell cell is fallback to Pcell in the time pattern: Qualcomm [27]

**Other:**

* Support for configured SPS HARQ-ACK PUCCH: Mediatek [16]

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

**General support for joint operation:**

* **Yes:** Huawei / HiSi [1], Ericsson [2] (incl. RRC state ‘dynamic & SS’), vivo [5], NEC [7], CATT [9] (?),
* **FFS:** Nokia/NSB [8] (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], Ericsson [2], vivo [5], NEC [7], Nokia/NSB [8] (from principle point of view), Samsung [15], Panasonic [21], FGI/APT [22]
* Subset of PUCCH carriers from the set / list of applicable PUCCH carriers can be configured for PUCCH carrier switching (applicable for both, semi-static and dynamic PUCCH cell switching): Ericsson [2]
* UE does not expect that the dynamically indicated target PUCCH cell is different from the PUCCH cell determined by switching pattern: CATT [9]
	+ *Moderator comment*: But wouldn’t this mean to just not to support the joint operation, and gNB configuring the semi-static pattern only (.. if anyhow the same PUCCH cell would need to be indicated, and then no additional DCI overhead)!?
* Multiplexing with PUCCH with dynamic cell indication is performed before applying semi-static PUCCH carrier switching. The multiplexed UCIs are transmitted on the cell of the PUCCH with dynamic cell indication: DoCoMo [18]
* Necessary to define which sets of HARQ-ACK timing values (configured for which cell) would be used for HARQ-ACK codebook construction: LGE [25]

**Joint operation of PUCCH carrier switching & SPS HARQ-ACK deferral:**

**Support semi-static PUCCH carrier switching and SPS HARQ-ACK deferral:**

* Yes: Huawei / HiSi [1], Ericsson [2], ZTE [3], Nokia/NSB [8] (could be),
* No: Spreadtrum [4], Intel [17] (for different numerologies / PUCCH slot length), DoCoMo [18], ETRI [20] (for different numerologies / PUCCH slot length)
* FFS: TCL [13] (consider when features are complete), Qualcomm [27] (study & decided)

**Support dynamic PUCCH carrier switching and SPS HARQ-ACK deferral:**

* Yes: Ericsson [2], ZTE [3], NEC [7], Nokia/NSB [8] (could be)
* No: Spreadtrum [4], Intel [17] (for different numerologies / PUCCH slot length), DoCoMo [18], ETRI [20] (for different numerologies / PUCCH slot length)
* FFS: TCL [13] (consider when features are complete), Qualcomm [27] (study & decided)
* Support semi-static but no mention of dynamic indication (i.e., Yes or No??): Huawei / HiSi [1], ZTE [3],

**Details:**

* For each candidate target slot/sub-slot, the UE will check its validity on its associated determined target PUCCH carrier, until an available PUCCH resource is identified to carry the deferred SPS HARQ-ACK: Huawei / HiSi [1], ZTE [3], Nokia/NSB [8], CATT [9] (PUCCH carrier switching first, SPS deferral check 2nd), LGE [25] (.. try PUCCH carrier switching first)
* The UE performs SPS HARQ-ACK deferral on the determined PUCCH cell: Ericssson [2] (incl. using configured ‘slot offset’ for time-domain based PUCCH carrier switching)
* Check the validity after determining the target cell (PUCCH carrier switching has higher priority): NEC [7]
* PUCCH carrier switching should be performed with high priority: Xiaomi [14]
* SPS HARQ-ACK deferral should not be further performed on switched PUCCH carrier: Xiaomi [14]
* The UE should be configured with sps-PUCCH-AN-List-r16 or n1PUCCH-AN PUCCH for each PUCCH carrier: Panasonic [21]

**Other:**

* Iterative PUCCH cell selection by Xiaomi [14]: Iterative PUCCH cell selection by the UE based on carrier priority (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):
	+ Step 1: Determine candidate carrier for PUCCH switching in order of priority
	+ Step 2: Determine HARQ-ACK reporting timing K1’on candidate carrier based on K1 value of original carrier
	+ Step 3: Determine PUCCH resource search space and search order based on K1’ on candidate carrier.
	+ Step 4: Check whether PUCCH resource within PUCCH resource search space of candidate carrier overlaps with “invalid symbol”. If yes, repeat step1 .Otherwise, the candidate carrier is identified as the target switching carrier.
		- The case of multiplexing and collision should not be considered on the switching PUCCH carrier
* Multiple carriers switching leading to the same initial carrier is allowed: Mediatek [16]
* HARQ-ACK codebook per PUCCH carrier to be supported: Mediatek [16]
* If LP-PUCCH transmission is overlapping with HP-CG-PUSCH, the UE prioritizes the transmission of PUSCH and the gNB needs to re-schedule the PUCCH transmission on different or same carrier. For HP-PUCCH re-use Rel-16 prioritization rules: Mediatek [16]
	1. Email approval of ‘stable’ proposals from RAN1#106-e (deadline Oct. 12th 5pm UTC)

The following stable proposals from RAN1#106-e are brought forward here directly, where only the cell / carrier issue has been changed. As we solved today the issue of SUL in the GTW session, I bring these proposals for email approval with 24hrs (5pm UTC, Tue Oct. 11th). As during the last meeting, let’s start using GTW here and I will move the remaining ones (hopefully all), to email tomorrow 2pm UTC (3hrs before the deadline).

**Proposal 6.4: For PUCCH 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 PUCCH 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)**
* **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***

|  |  |
| --- | --- |
| Objecting companies |  |

**Proposal 6.5: UE does not expect overlapping PUCCH slots with dynamic PUCCH cell indication on more than one cell, i.e., gNB should only dynamically indicate a single PUCCH cell for a final PUCCH slot.**

|  |  |
| --- | --- |
| Objecting companies |  |

**Proposal 6.6: For semi-static PUCCH 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** **PCell / PSCell / PUCCH-SCell ~~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 time-domain pattern is applied periodically**
	+ ***FFS on period / pattern length (e.g., 10ms, RRC configured,…).***
* **The pattern defines for each slot of the PCell / PSCell / PUCCH-SCell ~~reference cell~~ at least the applicable target PUCCH cell**

|  |  |
| --- | --- |
| Objecting companies | Ericsson( Not objecting, but we want to add an FFs that has RRC impact. Please see our comment.) |

**Proposal 6.7: For semi-static PUCCH cell switching, the PUCCH resource indicator (PRI) is interpreted based on the PUCCH configuration of determined target PUCCH cell.**

|  |  |
| --- | --- |
| Objecting companies |  |

**Proposal 6.8: The gNB will need to guarantee by configuration of the time-domain pattern for PUCCH cell switching, that the PUCCH cell switching points are to be aligned with PUCCH slot/sub-slot boundaries of a PUCCH cell.**

|  |  |
| --- | --- |
| Objecting companies | ZTE (not objecting, but try to clarify.) |

Please provide your comments here if objecting to any of Proposals 6.4 to 6.8 (no need to comment otherwise)

|  |  |
| --- | --- |
| *Company* | *Comments on Proposals 6.4 to 6.8 (if objecting)* |
| Ericsson | On Proposal 6.6:We have proposed to consider “slot-offset” in configuration of time pattern together with cell-index.’ Considering RRC impact, and also it solves the issue of different SCS, etc., we would like to discuss it.With adding the following FFS, we would be fine with the proposal.**FFS: configuration of slot-offset in time pattern.** |
| Samsung | Not objecting to anything but a short comment is still needed that the path-loss should be computed separately as this is for inter-band CA (even the optional *pathlossReferenceLinking* does not exist) – should be included in P 6.4. |
| Moderator | @Ericsson: we have the ‘at least’ there already that would allow to configure e.g. also some slot offset. * **at least the applicable target PUCCH cell**

Please note, that we did not really agree yet to support cases of different slot length and related handling (cmp. Aris’ comment in GTW session) – so there may not even be the case applicable. This is to be discussed in the mixed PUCCH length handling, which is currently not yet for discussion. @Samsung: good point, would Samsung raise this e.g. for next meeting with some discussions, so that I could refer to related Samsung discussions there? |
| ZTE | For proposal 6.8, maybe I missed something. I am not quite sure this can solve the issue of aligning the boundary. For example, if UE wants to switch from a short slot to a long slot, which boundary should be aligned? The boundary of short slot or long slot? If the boundary of short slot is aligned, it is obviously the switching is on the half of long slot. Maybe we can borrow some expression from proposal 6.5 and revise proposal 6.8 as :**For PUCCH cell switching based on semi-static patterns, UE does not expect overlapping PUCCH slots with semi-static time domain PUCCH cell indication on more than one carrier, i.e., gNB should only semi-static indicate a single PUCCH cell for a final PUCCH slot.** |
|  |  |

* 1. 1st Round of email discussions

**Agreements from RAN1#106bis-e so far (i.e., 1st GTW session):**

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| **Agreement**For PUCCH carrier switching, support PUCCH carrier switching only among different TDD cells with PUCCH configured on the NUL carrier in Rel-17**Agreement**For semi-static PUCCH cell switching, PCell / PSCell / PUCCH-SCell is reference cell:* The time domain pattern configurations are based on the numerology of the reference cell.
* 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 cell switching pattern.
* *Note: There may not be a need to define a ‘reference cell’ in the specification. This terminology is used for further clarifications of the procedure.*
 |

**Number of supported PUCCH cells:**

Also, on the number of supported cells, there is a wide range of options mention with restricting this to 2 cells in total up to not having any limitation (i.e., in principle up to the number of configured UL serving cells).

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| * **2 cells in total** (4 companies): vivo [5], CAICT [12], Samsung [15], Apple [26]
* **4 cells in total** (4 companies): ZTE [3], Nokia/NSB [8] (based on UE capability), CMCC [11] (for dynamic DCI indication), Panasonic [21] (UE capability indication if 2 or 4 are supported by UE),
* **Based on UE capability indication** (1 company): FGI/APT [22]
* **Up to maximum number of configured serving cells** (3 companies): ETRI [20], FGI/APT [22] (i.e., no limitation), CMCC [11] (for semi-static time-domain pattern)
 |

As this is having RRC impact as well and it may not be very easy to converge here by email discussion, the moderator proposes here to discuss the following compromise proposal, based on the following thinking:

* The max. number of PUCCH cells that can be configured should be a UE capability
	+ This allows for UEs only supporting e.g., 2 cells in total to support the feature, but at the same time allows more capable UEs to have more flexibility and being more future proof
* There may not be a need to go much beyond 4 cells in total, considering the potential gains here (so maybe as a compromise the maximum could be 4 from specification perspective).

There had been no consensus on the compromise proposal suggested by the moderator, so let’s check to see where companies stand:

**Question: Which of the following two alternatives do you support:**

* **Alt. 1 Compromise Proposal 6.2: For PUCCH cell switching, the UE indicates the maximum number of PUCCH cells that can be configured through UE capability signaling using a value range of {2, 3, 4} cells.**
	+ ***FFS: further details on UE capability indication (e.g., per band combination etc.)***
* **Alt. 2 Proposal 6.2: PUCCH cell switching between 2 cells is supported in Rel-17.**

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| Alt. 1 | Nokia/NSB, Intel, QC (2nd preference), Panasonic, LG, ZTE Huawei/Hisi (1st preference), MediaTek, DOCOMO, China Telecom…  |
| Alt. 2 | QC (1st preference), Samsung, CATT, vivo Huawei/Hisi (2nd preference) |

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| *Company* | *Comments*  |
| Nokia/NSB | Alt. 1 to be a bit future proof (as mentioned in GTW already) |
| Intel | Alt.1 is more flexible. Alt.2 is contained in Atl.1 by configuration. |
| QC | We can accept both alternatives, with slight preference on Alt 2.  |
| Ericsson | OK to Alt 1 |
| Samsung | There is no future-proofness that needs to be addressed and the support of the whole feature needs to strictly respect the agreement for “minimum specification impact”. In any foresseable future, there will be neither be a band combination with 3 TDD bands nor UEs with inter-band UL CA capability on 3 different bands. No need to introduce further UE capabilities that no UE will support in Rel-17 as no UE will support inter-band UL CA over 3 bands (never mind that practically no IIoT UE will support inter-band UL CA to begin with). Also, the majority of latency reduction can be achieved with one PUCCH SCell.  |
| vivo | We should aim for the minimum specification impacts. The maximum number has impacts on the L1, RRC signalling and UE capability. In addition, there is no use case for the PUCCH carrier switching cross 4 UL carriers that from different bands. Furthermore, for DSS that PCell cross-carrier scheduled by SCell, UL Tx switching, the number of the additional carrier is one. For Alt.1, is this UE capability per cell goup or per UE?  |
| ZTE | Share the views from Nokia and Intel. |
| Huawei/Hisi | The available NR TDD carrier number at FR1 would generally be up to 2 carriers. Regarding the wideband at FR2 (though FR2 may not be the first choice for URLLC use), there could be more TDD carriers available, so more than 2 carriers would be our 1st preference. Alt.2 can also be fine. |
| MediaTek | Alt-1 |

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

On the way the carrier is indicated, there is a majority of companies (7 vs. 4) proposing to utilize a dedicated DCI field for the indication and not to utilize the PRI for the indication, therefore, the following proposal is brought forward:

**Proposal 6.2.1: For PUCCH cell 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.**

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| Supporting companies | Nokia/NSB, QC, Samsung, CATT, vivo, TCL Huawei/Hisi, MediaTek, DOCOMO, China Telecom…  |
| Objecting companies | Panasonic, ZTE |

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| --- | --- |
| *Company* | *Comments*  |
| Intel | We are not objecting, but we prefer PRI. Fine if this is agreed by majority to move forward. |
| Ericsson | OK |
| Samsung | Other, roughly-equivalent, options exist but this is most consistent with “minimum specification impact”. |
| Panasonic | The separate field in DCI entails having the same size of PUCCH configurations among all the PUCCH carriers. While, the PRI usage enables defining different numbers of PUCCH configurations for carriers. If the current PRI size is not sufficient, the field size of PRI can be increased. The result is simialr to having dedicated DCI field. Extending the PRI field is more promising than introducing a separate carrier index field in the DCI because of the flexibilty. In addition, a dedicated field for carrier index is not efficient for supporting an odd number of carriers. |
| ZTE | We propose to reuse the PRI field for indication. |
| Huawei/Hisi | The PRI field is interpreted per PUCCH-config. The PUCCH resource sets for PRI are not available until a specific carrier index is obtained. |

**Additional cases of applicability of dynamic PUCCH cell indication:**

On the applicability for the dynamic indication, there had been several suggestions to add to the RAN1#106-e agreement (see in summary in 6.1). So, let’s see where companies stand here (direct proposals here as this is a Yes/No decision, clearly if they are not agreeable the current list of RAN1#106-e will be the final outcome), the cases include SPS PDSCH (without associated DCI based on the activation DCI), SCell dormancy indication and Rel-17 beam indication.

**Proposal 6.2.2: In addition, the dynamic target PUCCH cell indication also applies to SPS PDSCH HARQ-ACKs (without associated DCI).**

* **For SPS, the PUCCH cell indication is considered ‘dynamic’ only for the first HARQ-ACK, i.e., the PUCCH cell indication in the activation DCI, when applied for later SPS HARQ-ACKs, does not force to indicate the same PUCCH cell for HARQ-ACK of dynamically scheduled PDSCH to the slots with SPS HARQ-ACK.**

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| Supporting companies | Nokia/NSB, Intel, Samsung, vivo,TCL |
| Companies not supporting | QC Huawei/Hisi, DOCOMO |

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| *Company* | *Comments*  |
| QC | HARQ-ACK for SPS PDSCH other than the first one associated with activation DCI can/should use RRC configured time pattern. The motivation of extending dynamic carrier switch indication to SPS HARQ-ACK without associated activation DCI is not clear to us.  |
| Ericsson |  We have sympathy for QC’s explanation |
| Samsung | As the proposal is somewhat unclear, our understanding is that for HARQ-ACK that is for SPS PDSCH (does not relate to activation/release), either Rel-16 applies if the semi-static pattern is not configured, or the semi-static pattern applies if configured. DCI only applies for the “one-shot” indication by the DCI and does not have “sticking” power.  |
| CATT | The proposal is not clear to us. |
| Huawei/Hisi | Not clear about the sense of the bullet. Does it mean the later SPS HARQ-ACK except the first SPS after activation should follow the PCell/semi-static timing pattern? Or, does it mean the dynamic PUCCH cell indicated by DCI can be different with the PCell / Cell of semi-static pattern used for later SPS HARQ-ACKs (where the dynamically indicated SCell can overrid PCell/Cell of semi-static pattern)? |
| MediaTek | The proposal is not clear.  |
| DOCOMO | As analyzed in the sub-bullet, ovlapping of SPS HARQ-ACK slots on different PUCCH cells is possible. For such case, HARQ-ACK multiplexing would be complicated, e.g. how to determine the PUCCH cell for multiplexing of SPS HARQ-ACK on PUCCH Scell #1 and SPS HARQ-ACK on PUCCH Scell #2, when there is no HARQ-ACK with dynamic PUCCH cell indication multiplexed in the same HARQ-ACK CB?From simplicity perspective and considering the limited time for Rel-17, and without see any benefit, we don’t support the proposal. |

**Proposal 6.2.3: In addition, the dynamic target PUCCH cell indication also applies to HARQ-ACK corresponding to SCell dormancy indication.**

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| Supporting companies | Nokia/NSB, ASUSTeK, Samsung, CATT, vivo, ZTE Huawei/Hisi, MediaTek, DOCOMO |
| Companies not supporting |  |

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| --- | --- |
| *Company* | *Comments*  |
| QC | A question to FL for clarification: in our understanding Scell dormancy indication DCI may or may not schedule PDSCH data. If it schedules data, is its HARQ-ACK just viewed as a regular/norminal HARQ-ACK and PUCCH carrier switch can be applied on it? So the scope of this proposal is only for Scell dormancy indication DCI without scheduling PDSCH data? |
| Samsung | There will be several other cases in Rel-17, including for the HARQ-ACK retransmission without scheduling data from this WI. Can deprioritize that discussion for now – not urgent and totally a RAN1 issue.  |
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**Proposal 6.2.4: In addition, the dynamic target PUCCH cell indication also applies to HARQ-ACK corresponding to Rel-17 beam indication DCI for unified TCI without scheduling PDSCH.**

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| Supporting companies | ASUSTeK |
| Companies not supporting | Nokia/NSB, Intel, CATT, DOCOMO |

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| *Company* | *Comments*  |
| Nokia/NSB | Should be discussed (if at all) later on in the feMIMO WI. We have to focus here on Rel-16 & R17 URLLC enhancements (and try to complete these) and not start looking for issues / problems from other parallel WIs.  |
| Intel | We should not consider progress in other R17 items at this stage. Can revisit in Maintenance phase if any issues. |
| QC | No strong opinion here. We are fine to leave it up to MIMO group to decide. A question to FL for clarification: in our understanding unified TCI indication DCI may or may not schedule PDSCH data. If it schedules data, is its HARQ-ACK just viewed as a regular/norminal HARQ-ACK and PUCCH carrier switch can be applied on it? |
| ASUSTeK | We think PUCCH carrier switch based on dynamic indication can be supported for HARQ-ACK corresponding to any DL assignment since gNB could indicate PUCCH carrier by DCI. And, DL assignment includes Rel-17 beam indication DCI. But, we are fine to postpone making a decision in maintenance phase. |
| Samsung | Probably should not be supported or be configurable (which may not be decided in time).  |
| CATT | We share the same view as Nokia and Intel. |
| vivo | Deprioritize the discussion on this issue.  |
| MediaTek | We don’t see issue in supporting dynamic PUCCH cell indication for HARQ-ACK corresponding to Rel-17 beam indication DCI for unified TCI without scheduling PDSCH. |
| DOCOMO | Share similar view as Nokia and Intel |

**Multiplexing of UCI on PCell/PSCell on the dynamic dynamically indicated PUCCH cell:**

We have an agreement on the supported UCI types for semi-static operation, but not yet what happens for the case of dynamic indication, which includes:

* HARQ-ACK (e.g., SPS or scheduled by the fall-back DCI, if the dynamic indication is not applicable)
* SR
* CSI

Again, as each of them should be a binary decision, the related proposals one way is brought here directly. If not agreeable (or not a large majority), the assumption is that this is not supported.

**Proposal 6.2.5: Support multiplexing of HARQ-ACK (without dynamic PUCCH cell indication) on a dynamically indicated PUCCH cell.**

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| --- | --- |
| Supporting companies | Nokia/NSB, Panasonic, CATT, vivo, LG, DOCOMO |
| Companies not supporting | QC, Samsung Huawei/Hisi |

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| --- | --- |
| *Company* | *Comments*  |
| Nokia/NSB | Otherwise, there may be a need for parallel PUCCH or other handling (dropping) |
| Intel | We would like to clarify, what are the scenarios in mind when some HARQ-ACK information does not have associated PUCCH cell indication. Is that only the cases of fallback DCI scheduling? |
| QC | In general, we don’t support introduce a **new and complicated** feature to do UCI multiplexing cross multiple PUCCH cells (considering potential mixed numeroliges cross cells). On a slot N, if it is availabe to transmit HARQ-ACK without dynamic PUCCH cell indication on PUCCH cell X based on the time patter, there is no point for gNB to schedule dynamic PUCCH on a different PUCCH cell Y. In other words, gNB should avoid creating this parallel/overlapping PUCCH cross different PUCCH cells to begin with. Similar to “Proposal 6.5: UE does not expect overlapping PUCCH slots with dynamic PUCCH cell indication on more than one cell, i.e., gNB should only dynamically indicate a single PUCCH cell for a final PUCCH slot”, gNB should indicate a **same** PUCCH cell for HARQ-ACK with and without dynamic cell switch indication. Then, overlap and multiplexing between PUCCH with and without dynamic cell switch indication is allowed on the same cell. Current spec on PUCCH multiplexing can be reused for this case.  |
| Samsung | The proposal is too generic to be agreeable. Is the PUCCH/PUSCH with the HARQ-ACK to be multiplexed on the indicated PUCCH cell possible to transmit or not on its original cell? If it is possible to transmit (determined based on RRC rules), we do not support the proposal as it will require new multiplexing timelines and conditions for different SCS. Even for the same SCS, there is no reason to do PUCCH cell switching when there are resources for transmission of configured PUCCHs (on the P(S)Cell).In general, a DCI-based indication can create several new issues that are largely unnecessary and which we prefer to address by “UE does not expect” and abide by the “minimum specification impact”. In this case, we prefer a “UE does not expect to be indicated to transmit a first PUCCH on a PUCCH SCell when the would transmit a second PUCCH on the PCell”. Basically, anything that requires updating the R16 multiplexing/overlapping procedures/timelines is not acceptable.  |
| Moderator | @QC & Samsung: let’s see some further input from other companies. Clearly preventing as suggested by Samsung“UE does not expect to be indicated to transmit a first PUCCH on a PUCCH SCell when the would transmit a second PUCCH on the PCell”that would simplify the discussions here (e.g. on mixed numerology // PUCCH (sub-)slot length handling. I guess the same would then equally apply to SR & P/SP-CSI (as the same change would apply to these) and there would be no need for discussing 6.2.6/7/8 any further. Also the Type 1 HARQ-ACK codebook construction would be simplified. As said, let’s wait for further input (more opinions) here.  |
| vivo | To clear which cases are HARQ-ACK without dynamic PUCCH cell indication, maybe we can add a note to clarify that the HARQ-ACK without dynamic PUCCH cell indication includes the HARQ-ACK for the PDSCH scheduled by fallback DCI and SPS PDSCH without an associated DCI. |
| Samsung | @ModeratorWe make some related comments below in the discussion of later proposals. DCI-based indication can create several situations that need separate, and potentially complex, handling. We would prefer to avoid all that because (a) DCI-based indication is unnecessary in our opinion (the pattern is enough) and should not create situations that do not exist when the pattern is used and (b) the specification support for PUCCH cell switching, even at its bare minimum, is already way more than can be possibly justified by the usefulness of the PUCCH cell switching feature. If everything is allowed/supported, it is very doubtful IIoT will finish even in February.  |
| ZTE | Share some points from Qualcomm and Samsung. In this case, the dynamic PUCCH cell indication should indicate the PUCCH cell which carrying the SPS HARQ/SR/CSI.  |
| Huawei/Hisi | This question should be separately discussed for different HARQ-ACK types and CB types.If both HARQ-ACKs are scheduled by DCI (one cell with fallback DCI and the other with non-fallback DCI)* For Type 1 CB, this multiplexing should be avoided, since the k1 set for PCell/Cell of semi-static pattern can be different from the dynamically indicated Cell, so they cannot be easily combined into one CB.

* For Type 2 CB, this multiplexing may be considered, i.e., the multiplexing of HARQ-ACK happens in case their slot overlaps.

* But the overlapping of multiple short slots with HARQ-ACKs with one long slot with HARQ-ACK may be avoided due to its complexity.

* If the Non-fallback DCI schedules Type3/Enh. Type3/One-shot CB, it should follow the CB construction rule in Sec.3.

If one HARQ-ACK is SPS HARQ-ACK and the other is DG HARQ-ACK, this multiplexing may be considered, with the similar rule of Type 2 CB. |
| MediaTek | It will be good to understand the scenarios where this will occur before defining the behaviour. |

**Proposal 6.2.6: Support multiplexing of SR on a dynamically indicated PUCCH cell.**

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| Supporting companies | Nokia/NSB, Intel, Panasonic, vivo, LG Huawei/Hisi, MediaTek, DOCOMO |
| Companies not supporting | QC, CATT,  |

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| *Company* | *Comments*  |
| Nokia/NSB | No reason to not support SR to be transferred to indicated PUCCH cell (assuming SR resources are configured there in the slot) |
| QC | Same reason as for previous proposal, we don’t support this proposal due to 1) no motivation to support this case of cross CC PUCCH multiplexing; 2) unnecessary large spec impact. |
| Samsung | OK if no differentiation between SR and P/SP-CSI. Otherwise, and depending on other decisions, it would be better to exclude both.  |
| ZTE | Refer the response for proposal 6.2.5 |
| Huawei/Hisi | Same rule as in R15/R16, that SR can be multiplexed with HARQ-ACK in case of overlapping, where the only difference that the two UCIs are across carriers. |

**Proposal 6.2.7: Support multiplexing of P/SP-CSI on a dynamically indicated PUCCH cell.**

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| Supporting companies | Samsung Huawei/Hisi, DOCOMO |
| Companies not supporting | Nokia/NSB, QC, Panasonic, CATT, LG |

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| *Company* | *Comments*  |
| Nokia/NSB | No need identified, PCell should be available if P/SP-CSI is triggered.  |
| QC | Same reason as for previous proposal, we don’t support this proposal due to 1) no motivation to support this case of cross CC PUCCH multiplexing; 2) unnecessary large spec impact. |
| Samsung | If the gNB configured the UE to transmit P/SP-CSI, it is a rather sane conclusion that the gNB wants to receive it. There is no technical reason for prohibiting P/SP-CSI to be included, while enabling SR to be included, as there are no additional UE requirements/specifications. |
| vivo | No strong view, but same solution as for multiplexing SR can be used to multiplex P/SP-CSI on a dynamically indicated PUCCH cell. |
| ZTE | Refer the response for proposal 6.2.5 |
| Huawei/Hisi | Same rule as in R15/R16, that CSI can be multiplexed with HARQ-ACK in case of overlapping, where the only difference that the two UCIs are across carriers. |
| MediaTek | We do not see P/SP-CSI as essential as SR and HARQ-ACK. However, we can follow R15/R16 multiplexing rules. |
| DOCOMO | We prefer unified solution for UCI multiplexing. If multiplexing is not supported, when P/SP-CSI overlaps with PUCCH with dynamic PUCCH cell indication on a different cell, does that imply UE has to transmit simultaneous PUCCH in one PUCCH cell group? |

And when reading the contributions, it was not fully clear to the moderator (if multiplexing in principle is supported), if the multiplexing on the dynamically indicated PUCCH cell is performed if (i) the PUCCH resources are overlapping (i.e. the UE would first need to determine the PUCCH resource on the PCell and dynamically indicated PUCCH cell separately, before checking the multiplexing decision) or (ii) if only the PUCCH cell slots need to be overlapping (i.e. no need to determine the PUCCH resources e.g. for HARQ on several cells; this would more follow the HARQ-ACK multiplexing operation, i.e. all HARQ-ACK within a ‘slot’ is considered jointly on the dynamically indicated PUCCH cell only).

**Question 6.2.8: Applicable UCI is multiplexed on a dynamically indicated PUCCH cell if,**

* + **Alt. 1: the PUCCH resource of the UCI on PCell / PSCell / PUCCH-SCell and the PUCCH resource of UCI on the dynamically indicated PUCCH cell are overlapping**
	+ ***Note: in case of no PUCCH overlap, some specific handling would be needed (PUCCH on PCell / PSCell / PUCCH-SCell and dynamically indicated PUCCH cell)***
	+ **Alt. 2: if the slots (not necessarily the PUCCHs) of the UCI on PCell / PSCell / PUCCH-SCell and the dynamically indicated PUCCH cell are overlapping**
	+ ***Note: this does not require the PUCCH resources to be overlapping, i.e., all applicable UCI multiplexed on the dynamically indicated PUCCH cell***
	+ **Alt. 3: Other**

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|  Alt. 1 | Huawei/Hisi |
| Alt. 2 | Nokia/NSB, Intel, Panasonic, CATT, vivo, MediaTek, DOCOMO |
| Alt. 3 – other | QC, Samsung |

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| --- | --- |
| *Company* | *Comments*  |
| Nokia/NSB | Simplifies the operation, as otherwise we may have more than one HARQ-ACK transmission within a slot / sub-slot on different PUCCH cells (which the UE would not support) |
| Intel | Carrier switching within a slot (on sub-slot level) should be avoided. |
| QC | Same reason as for previous proposal, we don’t support this proposal due to 1) no motivation to support this case of cross CC PUCCH multiplexing; 2) unnecessary large spec impact. |
| Samsung | UE does not expect to be indicated PUCCH SCell for PUCCH transmission when the UE would transmit PUCCH on the P(S)Cell. PUCCH SCell switching is for avoiding dropped PUCCH transmissions. If the PUCCH on the P(S)Cell would be dropped based on RRC determination, there are no overlapping PUCCHs on different cells and the dropped UCI can go to the indicated PUCCH (as when there is no dropping and the DCI-indicated PUCCH resource is used).  |
| Panasonic | Alt. 2 has a lower complexility. |
| Moderator | @Samsung: the proposal above: “UE does not expect to be indicated to transmit a first PUCCH on a PUCCH SCell when the would transmit a second PUCCH on the PCell” or UE does not expect to be indicated PUCCH SCell for PUCCH transmission when the UE would transmit PUCCH on the P(S)Cell.Would this apply for overlapping PUCCH resources or overlapping PUCCH slots? This is maybe the thing I tried to discuss here, if we talk about ‘overlapping’ how the interpretation is here. Reason to discuss this: Let’s assume we have a slot based PUCCH even with the same numerology, if there would be a PUCCH with HARQ on PCell and a PUCCH on SCell which are not overlapping, which is still not against the two sentences above – there would be a need for a UE to support 2 PUCCHs in a slot – one on Scell and one on PCell with PUCCH carrier switching in the middle of the PUCCH slot. The same applies if we talk about SR and/or CSI. Having the ‘overlapping’ understanding her as ‘PUCCH slot overlapping’, there would not be such cases.  |
| Samsung | @ModeratorFine with overlapping PUCCH slots – it avoids some issues like having PUCCHs on both cells in a same slot (smaller SCS). To keep things simple, it will also be good to not have the PCell with larger SCS than the SCell (and that won’t affect anything in practice). Our underlying thinking should be that PUCCH cell switching is for when the PCell is not available – it is not for load balancing or for any other thing. We should not address cases where the PCell is available but the DCI indicates the SCell for PUCCH. Overall, we think that DCI-based indication was unnecessary to additionally support given the support of the RRC pattern – at least it should not also result to additional complexities – whenever needed, we prefer to address problematic cases due to DCI indication with “UE does not expect …” statements or even say nothing (just leave the UE behaviour undefined and is up to the NW not to create unnecessary problems).  |
| ZTE | If the UCI on PCell / PSCell / PUCCH-Scell is not SPS HARQ/SR/CSI, Alt.2 could be supported. |
| Huawei/Hisi | The multiplexing should be analysed depending on the UCI types.If the UCI on PCell / PSCell / PUCCH-SCell is CSI/SR, it should follow the R15/R16 multiplexing rule, i.e., the multiplexing occurs in case the PUCCH for CSI/SR is overlapped with the PUCCH for HARQ-ACK, regardless they are on the same cell or different cells.If the UCI on PCell / PSCell / PUCCH-SCell is HARQ-ACK (by DCI 1\_0 or SPS HARQ-ACK), it should consider the CB construction rule as analysed in Proposal 6.2.5 before the PUCCH resource is generated.  |
| MediaTek | For Alt. 2, we should consider the operation of sub-slot PUCCH as well. |
| DOCOMO | At least for HARQ-ACK multiplexing, slot/sub-slot overlapping is the multiplexing condition in Rel-15/16. To simplify handling, we are fine that slot/sub-slot overlapping condition also applies for other kinds of UCI multiplexing. |

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

**Pattern periodicity determination:**

There are different views on the time-domain pattern periodicity determination. Please provide your input on the following alternatives suggested by different companies:

**Question 6.2.9: The periodicity / length of the time-domain pattern for semi-static PUCCH cell switching is**

* + **Alt. 1: RRC configured, using candidate values of applicable periodicities from *dl-UL-TransmissionPeriodicity* and *dl-UL-TransmissionPeriodicity-v1530* (i.e. {ms0p5, ms0p625, ms1, ms1p25, ms2, ms2p5, ms3, ms4, ms5, ms10})**
	+ **Alt. 2: fixed to 10ms**
	+ ***Note: having fixed this to 10ms would create issues with 3ms / 4ms periodicity interaction***
	+ **Alt. 3: determined by the pattern length & periodicity given by *TDD-UL-DL-pattern* of the PCell / PSCell / PUCCH-SCell**
	+ **Alt. 4: directly determined by the configured length of the time domain pattern**
	+ **Alt. 5: Other**

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|  Alt. 1 | QC, CATT, vivo, LG Huawei/Hisi |
| Alt. 2 |  |
| Alt. 3  | Samsung, ZTE |
| Alt. 4 | Nokia/NSB, Panasonic, CATT, MediaTek, DOCOMO |
| Alt. 5 – other |  |

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| --- | --- |
| *Company* | *Comments*  |
| Nokia/NSB | We see no need for defining the periodicity. The pattern length (which is anyhow variable) can be directly used to define the pattern length based on gNB intention. The current RRC parameter structure supports length up to 10ms anyhow already.  |
| Intel | No strong preference, Alt.4 is slightly preferred |
| QC | With minimum spec impact and reusing existing periodicity signaling, Alt 1 seems the best approach.  |
| Ericsson | Alt 4 makes sense. The time domain pattern needs to be configured for every slot of the PCell. So the configured pattern can be repeated where the pattern length is implicitly the periodicity. |
| Samsung | No need to define multiple patterns. Pattern length & periodicity given by *TDD-UL-DL-pattern* of the P(S)Cell is enough. Of course, open to arguments why that may not be the case. |
| Moderator | @SamsungWhy ‘**minus PUCCH cell group**’?Don’t we still need this here, as we need this for DuCo as well as for NR CA with more than one PUCCH cell groups (i.e. for the secondary PUCCH cell group with NR CA). I thought we would support the PUCCH carrier swithing per PUCCH cell group, which would include dual-connecitivy operation as well as CA with more than one PUCCH cell group?  |
| vivo | Alt.1 is configurarable with reaonble value range. But Alt.4 is also configurable, what is the intention for Alt.4 or what the value should be defined for Alt.4? Anyhow we need sto define some value range for the periodicity, why not use Alt.1 to minimize the discussion efforts?  |
| Samsung | @ModeratorSorry for the confusion. PUCCH-SCell was misinterpreted to mean the SCell – that part is now removed. |
| DOCOMO | Slightly prefer Alt 4. And Alt 1/2/3 are also acceptable for us. |

**Interaction with PUCCH repetition**

The first question is how the UE determines the PUCCH repetition factor (based on which cell). DoCoMo suggesting the following, which seems to be very much reasonable:

**Proposal 6.2.10: For semi-static and dynamic indication of PUCCH cell switching, the PUCCH repetition factor is determined based on the PUCCH format or PUCCH resource on the target PUCCH cell after PUCCH cell switching.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, Intel, QC, CATT, vivo, LG, ZTE Huawei/Hisi (with clarification), DOCOMO |
| Companies not supporting |  |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Ericsson | Cant we have a high level agreement/conclusion instead of detailed proposal?Such that when PUCCH cell is changed, already exiting procedures are applicable. We can discuss if there are issues.  |
| Samsung | No problem with the intention but the proposal is not necessary. The general agreement that DCI overrides RRC is sufficient. Also, a “respectively” is needed. |
| Panasonic | First, we would like to know if the PUCCH are repeated in a single carrier or not. For the single carrier operation, the repetition factor for the PUCCH resource could be used. However, for the PUCCH repetitions over different carriers, the PUCCH resources could be configured with different repetitions factors. |
| Moderator | @Ericsson / Panasonic: 6.2.10 & 6.2.11 together would lead to the overall PUCCH repetition operation. As there are different views on 6.2.11 based on input contributions I splitted the two issues. @Samsung: Please note this is for both semi-static and DCI based. Clearly for dynamic indication, the repetition bundle should be clear but this more generic agreement would then also apply in case we support joint operation (DCI indicates the PUCCH carrier of the repetition bundle). ‘Respectively’ added.  |
| vivo | We are confused about the intention of the proposal until we saw Question 6.2.11.So maybe we can first discuss the Question 6.2.11. |
| Samsung | @ModeratorThank you for the clarification. Objection removed. However, there does not seem to be a need for an agreement – this proposal seems to be a conclusion. We understand that if the UE does not support Rel-17 CovEnh for PUCCH, Rel-16 applies. Otherwise, for DCI-based PUCCH, Rel-17 applies (and for RRC-based PUCCH, Rel-16 applies but that may need to wait for confirmation after this meeting). What is the new UE behavior that needs to be agreed?  |
| Huawei/Hisi | It is not clear about the precise meaning of ‘after PUCCH cell switching’. Does it mean the first PUCCH repetition (according to the configured time position or dynamically indicated time position)? Try to modify as follows**Proposal 6.2.10: For semi-static and dynamic indication of PUCCH cell switching, the PUCCH repetition factor is determined based on the PUCCH format or PUCCH resource on the target PUCCH cell ~~after PUCCH cell switching~~ for the first repetition.** |
| Moderator | @Huawei: this was my intention. Much better formulation from your side. Will update this in 2nd round accordingly (now a bit late to update for the 1st round) |

There are different views on the how to operate the semi-static switching with PUCCH repetition, i.e., if switching within a repetition bundle is allowed or not. Please provide your input on the following alternatives:

**Question 6.2.11: For semi-static PUCCH cell switching and PUCCH repetition:**

* + **Alt. 1: The target PUCCH cell is determined for each PUCCH repetition individually**
	+ **This may include the limitation of cell switching of the same SCS / PUCCH slot length**
	+ **Alt. 2: A PUCCH repetition mapping to a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition is not supported (i.e., the target PUCCH cell determination only applies to the first PUCCH repetition)**
	+ **Alt. 3: Other**

|  |  |
| --- | --- |
|  Alt. 1 | Samsung, Panasonic Huawei/Hisi, MediaTek |
| Alt. 2 | Nokia/NSB, Intel, QC, CATT, vivo,LG, ZTE, DOCOMO |
| Alt. 3 – other |  |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| Nokia/NSB | Alt. 2 simplifies the operation. For Alt. 1, there maybe different PUCCH repetition factors configured for different PUCCH cells, so extra handling would be needed. Moreover, PUCCH repetition with mixed SCS would require further handling for Alt. 1.  |
| Intel | As was discussed for SPS HARQ-ACK deferral, PUCCH repetition has its own deferral process specified. This needs to be discussed / handled if per-repetition cell switching is allowed. We think to simply discussion, Alt. 2 is a better choice. |
| QC | Alt. 2 minimize the spec impact. A UE just determines the target cell for the first repetition reusing the procedure for PUCCH without repetition (as if there is repetition). Then the UE reuses the Rel-15 PUCCH repetition proceure on the determined target cell for the rest of repetitions. An FFS on Alt 2 is that for rest of the repetitions, whether UE reuse Rel-15 behavior to transmit all remaining repetitions or introducing some dropping behavior to drop certain repetitions as proposed by DCM in their Tdoc. This can be discussed further.  |
| Ericsson | Alt 2 is OK. Simple |
| Samsung | No need for different UE behaviors depending on whether or not a PUCCH is with repetitions – at a given slot, the UE transmits the PUCCH where the pattern tells the UE to transmit the PUCCH. |
| Panasonic | The PUCCH repetitions over different carriers ensure lower latency to perform all the repetitions. |
| Huawei/Hisi | Allowing PUCCH repetition over available cells can help to reduce the latency, which is also the motivation of introcuding PUCCH carrier switching. The repetition factor coud be simply defined as the factor corresponding to the first PUCCH repetition. If there is concern on the numerology, we may limit the PUCCH repetition across cells is enabled only if all available carriers are with the same numerology and PUCCH slot length. |
| DOCOMO | We don’t support Alt 1 since PUCCH resource and related parameters for repetitions on different PUCCH cells may be not same. For such case, soft combining gain may be lost.  |

**HARQ-ACK codebook construction**

For dynamically indicated PUCCH carrier switching, there had been little input on how to operate the Type 1 and Type 2 CB construction (which seems to be a reason of the slightly unclear operation of the supported multiplexing there). For the semi-static operation, this seems to be easier here to have some related clarifications agreed.

**Proposal 6.2.12: For semi-static PUCCH cell switching, the Type 1 HARQ-ACK codebook construction is based on the configured K1 set(s) of the PCell / PSCell / PUCCH-SCell.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, Panasonic, CATT, vivo, LG Huawei/Hisi, MediaTek, DOCOMO |
| Companies not supporting | QC |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| QC | Before considering this proposal, can we please clarify one question: whether semi-static PUCCH cell switch can be applied to PDSCH scheduled by DCI without the dynamic cell indication field? If the answer is no, then semi-static PUCCH cell switch only applies to A/N for SPS PDSCH. For SPS A/N there seems no concept of type 1 or type 2 codebook and the proposal is not needed. If the answer is yes, we see the motivation to discuss this proposal. |
| Samsung | PUCCH switching is to provide resources for a UE to transmit a PUCCH that the UE cannot on the P(S)Cell. The PUCCH-SCell is not yet another P(S)Cell and the UE does not need to be computing two (or more if more than 1 PUCCH SCell) HARQ-ACK codebooks. No change to the Rel-16 Type-1 codebook construction (with the Rel-17 sub-slot support). |
| Moderator | @Qualcomm: this is now for stand-alone PUCCH carrier switching operation only (we have not even agreed to support joint operation of SS & dynamic PUCCH carrier switching indication). So in here, the is no dynamic indication (as this is the time-domain pattern – ‘semi-static’). @Samsung: the intention is to say we don’t need a change of the Type 1 CB construction procedure. But it should still be clarified which K1 set(s) are to be used – or does Samsung think this is already captured by Mon GTW agreement:* *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 cell switching pattern.*

**On the PUCCH-Scell**, don’t we still need this here, as we need this for DuCo as well as for NR CA with more than one PUCCH cell groups (i.e. for the secondary PUCCH cell group with NR CA). I thought we would support the PUCCH carrier swithing per PUCCH cell group, which would include dual-connecitivy operation as well as CA with more than one PUCCH cell group?  |
| Samsung | @ModeratorThanks for the explanation for the PUCCH-SCell – the intention is now understood and is fine. It was interpreted as being the SCell where PUCCH is transmitted due to switching (need to start using some new term for that SCell).Regarding the Type-1 CB construction, yes, agree that the K1 sets should be identified. Removed the objection. However, the proposal needs more details (e.g. take union of K1 sets, or take intersection, or have separate construction of multiple/2 Type-1 CBs for each of the multiple/2 cells (probably necessary for different SCS), …) – as it is now, it just identifies that something beyond R16 needs to be done. Would be good to discuss restrictions to what it should be supported - the complexity burden for supporting the feature is becoming way larger than what the feature is worth.  |
|  |  |

**Modified Proposed Conclusion 6.2.13: For semi-static PUCCH cell switching, the Rel-16 Type 2 HARQ-ACK codebook construction can be directly reused ~~based on the PCell / PSCell / PUCCH-SCell (configuration & numerology)~~.**

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB, Panasonic, CATT, vivo, LG, Samsung Huawei/Hisi, MediaTek, DOCOMO |
| Companies not supporting | QC |

|  |  |
| --- | --- |
| *Company* | *Comments*  |
| QC | Before considering this proposal, can we please clarify one question: whether semi-static PUCCH cell switch can be applied to PDSCH scheduled by DCI without the dynamic cell indication field? If the answer is no, then semi-static PUCCH cell switch only applies to A/N for SPS PDSCH. For SPS A/N there seems no concept of type 1 or type 2 codebook. Even if the answer is yes, we still fail to see why the proposal is needed. In our understanding, type 2 codebook construction is based on the DAI where DAI has not nothing to do with PCell / PSCell / PUCCH-SCell configuration & numerology. |
| Samsung | No need to consider the PUCCH-SCell for the Type-2 CB construction – similar comment as for the previous proposal. |
| Moderator | @Qualcomm: this is now for stand-alone PUCCH carrier switching operation only (we have not even agreed to support joint operation of SS & dynamic PUCCH carrier switching indication). So in here, the is no dynamic indication (as this is the time-domain pattern – ‘semi-static’). But agree with the point that this is independent of numerology (updated).  |
| Samsung | @ModeratorThanks for the update – objection is now switched to support. |
|  |  |

# Other proposals (not directly related to Sec. 2-6 / agreed Rel-17 HARQ enhancements)

* Xiaomi [14] proposes NACK and ACK skipping (which was precluded by RAN #92) and HARQ bundling / compression
* Increase the number of reserved REs for HARQ-ACK on PUSCH: Samsung [15] (see details in Sec. 2.6 of [15])
* Remove duplicated HARQ-ACK information from the Type-1 HARQ-ACK codebook for intra slot PDSCH repetition: Samsung [15] (see details in Sec. 2.7 of [15])
* The HARQ-ACK timing indicator counts only slots with PUCCH resources: Samsung [15] (see details in Sec. 2.8 of [15])

# RRC parameter related proposals

**PUCCH carrier / cell switching:**

* Huawei / HiSi [1]
	+ Change “*pucch-SCellList*” to “*pucch-CarrierList*”
	+ change “SCellIndex” in the value of range to “ServCellIndex”.
	+ For NUL/SUL differentiation, for the same ServCellIndex the first appearance in the list could be directly associated with ‘NUL’ and the second appearance with ‘SUL’
	+ RRC parameter *tpc-IndexPUCCH-Carrier-list* with the range of “*SEQUENCE SIZE ((1…X)) of tpc\_IndexPUCCH-CarrierSwitch*” and RRC parameter *tpc\_IndexPUCCH-CarrierSwitch* are introduced to configure a set of candidate PUCCH carriers for TPC.
* Ericsson [2]
	+ General / overall comments:
		- Column J (description): Should be suitable as “field description” for the RRC specification. i.e. it should clarify what the UE does when the NW sets the field. Should e.g. contain the unit of the numerical values. Short and concrete descriptions are preferred.
		- Column P (Comments): Should contain background information from RAN1 to RAN2 that helps RAN2 to understand the context and the feature.
		- Column M (per...): May also contain the name of a parent IE that RAN1 considers appropriate.
		- Column E (RAN2 Patent IE): Should be left empty. Provide information on Parent IE in Column M, if needed.
		- Column F (RAN2 ASN.1 name): Should be left empty.
		- Using ToAddModList and ToReleaseList sructures: Suggest to leave it to RAN2 to whether to use these structures or other methods for proper implementation of signalling.
	+ General proposal:
		- Move content of Column E to Column M
	+ SPS deferral - Row 2:
		- Update column J (Description): “When spsHARQdeferral-max is present, transmission of DL SPS HARQ-ACK can be deferred to a later slot as described in Clause [9.2.3] of TS38.213. spsHARQdeferral-max is the maximum number of slots from a DL SPS slot to deferred HARQ-ACK slot.”
		- Change {} to () in Column J
	+ PUCCH repetition – Row 3:
		- Remove row 3.
		- Add ‘format 0’ under PUCCH-Config, and remove the restriction for ‘nrofSlots’ to be applicable to F0/1/2/3/4. Describe other parameters in ‘PUCCH-FormatConfig’ such as ‘interslotFrequencyHopping’, ‘pi2BPSK’, ‘simultaneousHARQ-ACK-CSI’, and ‘maxCodeRate’ are not applicable for format 0.
	+ Enhanced Type 3 CB:
		- Change subfeature group name (Column B) to “Enhanced Type 3 HARQ-ACK CB”
		- Change “enhanced” and “enh.” to “reduced size” in Column J
	+ One-shot HARQ triggering
		- Change Description (Column J) to “Configure triggering of HARQ-ACK re-transmission on a PUCCH resource as described in Clause [x.x] in TS38.213”
* vivo [5]
	+ DCI format 1\_2 with enh. Type 3 CB:
		- *RAN1 determines to introduce separate RRC parameters, including pdsch-HARQ-ACK-OneShotFeedbackCBGDCI-1-2 and pdsch-HARQ-ACK-OneShotFeedbackNDIDCI-1-2, to control the content or structure of a Rel-16 Type-3 codebook triggered by a DCI format 1\_2 independently, or alternatively clarifies that these RRC parameters for DCI format 1\_2 reuse the corresponding one defined currently for DCI format 1\_1*.
* CMCC [11]
	+ The RRC IE could be formed as something like the following, just as an illustration:

PUCCH-carrier-index ::= SEQUENCE {

Slot0 ServCellIndex,

Slot1 ServCellIndex,

Slot2 ServCellIndex,

…… ……

Slot19 ServCellIndex

}

* ETRI [20]
	+ The *pdsch-HARQ-ACK-enhType3NDI* may not needed for URLLC operations.
	+ The *pdsch-HARQ-ACK-enhType3CBG* may not needed for URLLC operations
* LGE [25]
	+ SPS HARQ-ACK deferral for a SPS configuration is enabled by configuring maximum deferral value in the SPS configuration

# References

1. R1-2108726 UE feedback enhancements for HARQ-ACK Huawei, HiSilicon
2. R1-2108829 HARQ-ACK Enhancements for IIoT/URLLC Ericsson
3. R1-2108840 Discussion on HARQ-ACK enhancements for eURLLC ZTE
4. R1-2108906 Discussion on HARQ-ACK feedback enhancements for Rel-17 URLLC Spreadtrum Communications
5. R1-2108966 HARQ-ACK enhancements for Rel-17 URLLC vivo
6. R1-2109093 HARQ-ACK enhancements for Rel-17 URLLC/IIoT OPPO
7. R1-2109131 UE feedback enhancements for HARQ-ACK NEC
8. R1-2109159 HARQ-ACK Feedback Enhancements for URLLC/IIoT Nokia, Nokia Shanghai Bell
9. R1-2109215 UE feedback enhancements for HARQ-ACK CATT
10. R1-2109256 Discussion on some remaining issues for UE HARQ-ACK feedback enhancements China Telecom
11. R1-2109277 Discussion on UE feeback enhancements for HARQ-ACK CMCC
12. R1-2109342 UE feedback enhancements for HARQ-ACK CAICT
13. R1-2109354 UE feedback enhancements for HARQ-ACK TCL Communication Ltd.
14. R1-2109406 UE feedback enhancements for HARQ-ACK Xiaomi
15. R1-2109482 On HARQ-ACK reporting enhancements Samsung
16. R1-2109575 On UE feedback enhancements for HARQ-ACK MediaTek Inc.
17. R1-2109604 Remaining issues of enhanced HARQ-ACK feedback procedures Intel Corporation
18. R1-2109671 Discussion on HARQ-ACK feedback enhancements for Rel.17 URLLC NTT DOCOMO, INC.
19. R1-2109782 Considerations on HARQ-ACK enhancements for URLLC Sony
20. R1-2109809 UE feedback enhancements for HARQ-ACK ETRI
21. R1-2109821 Discussion on UE feedback enhancements for HARQ-ACK Panasonic
22. R1-2109822 Discussion on UE feedback enhancements for HARQ-ACK FGI, Asia Pacific Telecom
23. R1-2109893 HARQ enhancements for IIoT and URLLC InterDigital, Inc.
24. R1-2109940 HARQ-ACK feedback enhancement for IIoT/URLLC Lenovo, Motorola Mobility
25. R1-2109970 Discussion on UE feedback enhancement for HARQ-ACK LG Electronics
26. R1-2110027 Rel-17 URLLC UE feedback enhancements for HARQ-ACK Apple
27. R1-2110178 HARQ-ACK enhancement for IOT and URLLC Qualcomm Incorporated
28. R1-2110244 On the UE feedback enhancements for HARQ-ACK ITRI
29. R1-2110287 Discussion on PUCCH carrier switch for HARQ-ACK enhancement ASUSTeK

# 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 (RED):

* 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

**Agreement**

For SPS HARQ-ACK deferral, the maximum deferral value in terms of k1+k1def is RRC configured per SPS configuration.

**Agreement**

For SPS HARQ-ACK deferral, only SPS HARQ bits subject to deferral from HARQ-ACK codebook from an initial PUCCH slot are deferred to the target PUCCH slot

**Agreement**

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

**Agreement**

Confirm the following RAN1#105-e 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 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, …).

**Agreement**

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.

**Agreement**

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.

**Agreement**

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.

**Agreement**

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.

**Agreement**

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.

**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

**Agreement**

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**

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.

**Agreement**

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.

**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.

**Agreement**

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

**Agreement**

For SPS HARQ-ACK deferral, the target PUCCH slot is defined as the next PUCCH slot where *sps-PUCCH-AN-List-r16* or*n1PUCCH-AN* PUCCH resource is regarded as valid*,*or a 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
* 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.

**Agreement**

For SPS HARQ-ACK deferral, if after the target PUCCH slot determination the deferred SPS HARQ-ACK cannot be transmitted, the deferred SPS HARQ-ACK bits are not further deferred and are dropped.

**Agreement**

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.

**R1-2108546** Moderator summary #3 on HARQ-ACK feedback enhancements for NR Rel-17 URLLC/IIoT Moderator (Nokia)

**Agreement**

For SPS HARQ-ACK deferral, confirm the RAN1#104b-e working assumption with the following updates in RED:

(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 of DG PDSCH with the same HARQ process ID

**Agreement**

For enh. Type 3 HARQ-ACK CB(s), support dynamic selection based on indication in the triggering DCI of one of at least one enh. Type 3 HARQ-ACK CB(s).

* Each of the at least one enh. Type 3 HARQ-ACK CBs is at least defined by RRC configuration This includes the option to configure all DL HARQ processs of all configured CCs as one enh. Type 3 HARQ-ACK CB (resulting in same structure and size as the Rel-16 Type 3 HARQ-ACK CB)
* This includes UE capability signaling (value range {1…X}) on the maximum number of supported simultaneously configured enh. Type 3 HARQ-ACK CBs that can be dynamically indicated
* Details including the value of X are FFS

**Agreement**

The following enhanced Type 3 CB types of smaller size are supported, the CB to contain either:

* the HARQ processes of a subset of configured CCs, or
* a subset of configured HARQ processes (specific to CCs)

FFS: additional enh. Type 3 CB types

**Agreement**

For Rel-17 one-shot triggering for HARQ-ACK re-transmission, 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

**Agreement**

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

**Agreement**

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

**Agreement**

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

# Appendix B: Summary of companies’ proposals

In here, the proposals and some example figures are collected for easier referencing.

### R1-2108726 UE feedback enhancements for HARQ-ACK Huawei, HiSilicon

**Proposal 1:** ***During the target PUCCH slot determination for a candidate slot/sub-slot, if the PUCCH resource determined by the total payload size of deferred SPS HARQ-ACKs and/or non-deferred SPS HARQ-ACKs is invalid,***

* ***The deferred SPS HARQ-ACKs and/or non-deferred SPS HARQ-ACKs that have reached the maximum deferral value and that are configured without deferral are dropped, and the rest SPS HARQ-ACKs are deferred to the next candidate slot/sub-slot.***
* ***Dropping partial SPS HARQ-ACKs for the purpose of re-determining a valid PUCCH resource should not be considered.***

**Proposal 2:** ***For deferred SPS HARQ-ACKs, it should be further discussed whether CG/DG-PUSCH and PUCCH resource for CSI report(s) provided by PUCCH-CSI-ResourceList* or *multi-CSI-PUCCH-ResourceList should be regarded as available resource in the target PUCCH slot/sub-slot.***

***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 3：*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 4: *For PUCCH carrier switching, down-selection one of the following options:***

* ***Option 1: 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***
* ***Option 2: PUCCH carrier switching is only performed among different TDD cells in Rel-17.***

**Proposal 5: *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 carrier.***

**Proposal 6: *An RRC parameter pucch-CarrierList with the range of “SEQUENCE (SIZE (1..X)) OF ServCellIndex” is introduced to configure a set of candidate PUCCH carriers for PUCCH carrier switching.***

* ***If one certain ServCellIndex is configured twice by pucch-CarrierList, the first value and the second value correspond to NUL and SUL of the cell with ServCellIndex, respectively. Otherwise, it corresponds to either SUL or NUL depending on which is configured with PUCCH transmission.***

**Proposal 7:** ***The NUL carrier of PCell is the reference carrier for time-domain pattern configuration for semi-static PUCCH carrier switching.***

**Proposal 8: *For configuration of the RRC configured PUCCH carrier timing pattern,***

* ***The granularity of the timing-domain pattern is based on the SCS of NUL carrier of PCell.***
* ***K1 interpretation is based on the numerology and K1 set which are configured for the NUL carrier of PCell.***
* ***PRI interpretation is based on the PUCCH configuration for the target PUCCH carrier.***

**Proposal 9: *An RRC parameter pucchCarrierPattern with the range of “SEQUENCE (SIZE (1..maxNrofSlots)) of INTEGER(1..X)” is introduced***

* ***Value x of the “INTEGER(1..X)” represents the x-th carrier of “PUCCH-CarrierList”***

**Proposal 10: *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 11: *For PUCCH repetition with PUCCH carrier switching, consider to determine the target carrier for each PUCCH repetition individually based on the available carrier of the slot.***

**Proposal 12: *RRC parameter tpc-IndexPUCCH-Carrier-list with the range of “SEQUENCE SIZE ((1…X)) of tpc\_IndexPUCCH-CarrierSwitch” and RRC parameter tpc\_IndexPUCCH-CarrierSwitch are introduced to configure a set of candidate PUCCH carriers for TPC.***

**Proposal 13: *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 14: *Support joint operation of semi-static 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 15: *For dynamic HARQ-ACK scheduled by fallback DCI with DCI format 1\_0,***

* ***If there is no HARQ-ACK scheduled by non-fallback DCI with dynamic carrier indication that it can multiplex with in a slot/sub-slot***
	+ ***If semi-static carrier switching is configured, it will be transmitted at a carrier based on semi-static carrier pattern,***
	+ ***Otherwise, it should be transmitted on the PCell.***
* ***If there is HARQ-ACK scheduled by non-fallback DCI with dynamic carrier indication that it can multiplex with in a slot/sub-slot, it can be multiplexed with the HARQ-ACK scheduled by non-fallback DCI and transmitted on the carrier indicated by non-fallback DCI***

**Proposal 16: For triggering Rel-17 enh. Type 3 CB,**

* ***If one enh. Type 3 CB is configured, the DCI can also be used to schedule PDSCH, and the legacy ‘one-shot HARQ-ACK request’ field can be used to trigger this configured enh. Type 3 CB.***
* ***If more than one enh. Type 3 CB are configured, the DCI should not be used to schedule PDSCH, and some unused fields can be re-interpreted to indicate the specific enh. Type 3 CB.***

**Proposal 17: *Rel-17 one-shot triggering for HARQ-ACK re-transmission should be triggered by DCI without scheduling PDSCH, and some unused fields can be re-interpreted to enable the HARQ-ACK re-transmission and indicate the backward slot-offset.***

**Proposal 18: *For Rel-17 one-shot triggering for HARQ-ACK re-transmission, consider the backward slot-offset to be the gap between the dropped PUCCH and the new target PUCCH for HARQ-ACK re-transmission.***

**Proposal 19: *For Rel-17 one-shot triggering for HARQ-ACK re-transmission, support the re-transmitted HARQ-ACK CB to be multiplexed with another initial Type 1/Type 2 HARQ-ACK CB in case of collision.***

**Proposal 20: *For Rel-17 one-shot triggering for HARQ-ACK re-transmission, the DCI missing issue should be resolved by introducing a DAI field to help identifying the CB size of the dropped HARQ-ACKs.***

### R1-2108829 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 SPS HARQ-ACK is performed if needed on the determined PUCCH cell.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035578)[Observation 2 The main enhancement for Type-3 HARQ-ACK CB should be enabling Type-3 HARQ-ACK CB to operate with two-level priorities.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035579)[Observation 3 The claimed shortcoming of using that a full-size Type-3 CB (i.e. as in Rel-16) is not justified.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035580)[Observation 4 The claimed flexibility provided by dynamic selection between multiple reduced sized Type-3 HARQ-ACK CB is not justified.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035581)[Observation 5 One-shot triggering of HARQ-ACK retransmissions is only justified when it is applied to event intentionally caused by gNB where the mis-reception of original HARQ-ACK CB is due to a reason known to gNB.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035582)[Observation 6 One-shot triggering of HARQ-ACK retransmissions is not justified to emulate repetition.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035583)[Observation 7 One-shot triggering of HARQ-ACK retransmission is motivated only for retransmission of the dropped HARQ-ACK CB.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035584)[Observation 8 The semi-static configuration of PUCCH cell timing pattern containing ‘slot\_offset’ parameter can be used to obtain the SPS HARQ-ACK deferral behavior.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035585)[Observation 9 The discussion should be focused on functionalities and corresponding analysis than feature names.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035586)[Observation 10 The current agreements support Case 1 and Case 2-1 as opposed to Case 2-2 and Case 3.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035587)[Observation 11 Case 3 is out of scope based on the current agreements.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035588)[Observation 12 Case 2-2 and Case 3 cannot be separately discussed.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035589)[Observation 13 Support of PUCCH carrier switching for Case 2-2 or 3 with minimum specification impact is questionable.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035590)[Observation 14 Support of PUCCH carrier switching for Case 2-2 or 3, requires specification of new behaviors at least for PUSCH scheduling by DCI 0\_0 and power control.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035591)[Observation 15 Support of PUCCH carrier switching for Case 2-2 or 3, requires additional configuration at least for PUCCH configuration with reduction of number of PUCCH resources for both NUL and SUL.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035592)[Observation 16 The following general guidelines are recommended for preparation of the RRC parameter list:](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035593)[· Column J (description): Should be suitable as “field description” for the RRC specification. i.e. it should clarify what the UE does when the NW sets the field. Should e.g. contain the unit of the numerical values. Short and concrete descriptions are preferred.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035594)[· Column P (Comments): Should contain background information from RAN1 to RAN2 that helps RAN2 to understand the context and the feature.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035595)[· Column M (per...): May also contain the name of a parent IE that RAN1 considers appropriate.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035596)[· Column E (RAN2 Patent IE): Should be left empty. Provide information on Parent IE in Column M, if needed.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035597)[· Column F (RAN2 ASN.1 name): Should be left empty.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035598)[· Using ToAddModList and ToReleaseList sructures: Suggest to leave it to RAN2 to whether to use these structures or other methods for proper implementation of signalling.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035599)[Observation 17 Proposals 27 to 31 are summarized in Table 2 on the applicable rows and columns where changes are shown in purple color.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035600)Based on the discussion in the previous sections we propose the following:[Proposal 1 If UE is configured with both PUCCH carrier switching and SPS HARQ-ACK deferral, the UE performs SPS HARQ-ACK deferral on the determined PUCCH cell.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035601)[Proposal 2 Support the value range of the maximum value of K1+ K1def for SPS HARQ-ACK deferral (1…15).](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035602)[Proposal 3 When the SPS HARQ-ACK is part of a PUCCH repetition which partially overlaps with other PUCCH repetitions containing HARQ-ACK, the overlapping PUCCH repetition carrying SPS HARQ-ACK can be deferred further following the Rel-17 SPS HARQ-ACK deferral.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035603)[Proposal 4 The maximum number of supported simultaneously configured enhanced Type 3 HARQ-ACK CBs can be 1, i.e., X=1.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035604)[Proposal 5 The UE can be configured with either Rel-16 Type-3 HARQ-ACK CB or Rel-17 enhanced Type-3 CB to operate with full-sized or reduced sized Type-3 CB.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035605)[Proposal 6 The existing 1-bit DCI field for triggering Type-3 CB is reused to trigger the full-sized or reduced-sized Type-3 CB, whichever is configured.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035606)[Proposal 7 The enhanced Type-3 HARQ-ACK CB supports additional configurations of NDI reporting and CBG level A/N. The configurations are optional and can be separately configured.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035607)[Proposal 8 DCI formats 1\_1 and 1\_2 are supported for one-shot triggering of HARQ-ACK retransmission.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035608)[Proposal 9 For one-shot triggering of HARQ-ACK retransmission, the dynamic triggering is to request for the last dropped HARQ-ACK codebook.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035609)[Proposal 10 One-shot triggering of HARQ-ACK retransmission does not restrict the possibility of simultaneously scheduling PDSCH.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035610)[Proposal 11 For HARQ-ACK CB construction related to one-shot triggering of HARQ-ACK retransmission, the triggered retransmitted HARQ-ACK is appended to the HARQ-ACK CB corresponding to the scheduled PDSCH or the HARQ-ACK CB in a PUCCH slot constructed according to Rel-15/16 procedure.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035611)[Proposal 12 For sub-slot based PUCCH repetition using the parameter *nrofSlots*, the PUCCH repetition is applied to only HARQ-ACK.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035612)[Proposal 13 RAN1 can conclude that there is no need for a special handling of time gap between PUCCH repetitions.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035613)[Proposal 14 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](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035614) $2μDL-μUL$ is changed to $2μDL-μUL/N$, where N is the number of sub-slots in an UL slot.[Proposal 15 Dynamic indication of a PUCCH carrier is done by a field in the DCI. The DCI field size is determined based on the size of a configured set of applicable target PUCCH cells.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035615)[Proposal 16 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.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035616)[Proposal 17 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.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035617)[Proposal 18 PUCCH carrier switching can be dynamic, semi-static, or both by configuration .](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035618)[Proposal 19 A subset of applicable PUCCH cells for PUCCH carrier switching within a PUCCH group can be configured to a UE per PUCCH group.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035619)[Proposal 20 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.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035620)[Proposal 21 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.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035621)[Proposal 22 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.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035622)[Proposal 23 The UE does not expect to be indicated with HARQ-ACK transmission in PUCCHs overlapping in different PUCCH carriers.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035623)[Proposal 24 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.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035624)[· 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.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035625)[Proposal 25 RAN1 should proceed on completing the design of PUCCH carrier switching for Case 1 and Case 2-1.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035626)[Proposal 26 The discussion for Case 2-2 and/or Case 3 should be deprioritized.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035627)[Proposal 27 Move content of Column E to Column M.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035628)[Proposal 28 Apply the following updates for Row 2:](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035629)[Proposal 29 Remove Row 3. Instead, suggest to RAN2 if the feature can be implemented as the following:](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035630)[· Add ‘format 0’ under PUCCH-Config, and remove the restriction for ‘nrofSlots’ to be applicable to F0/1/2/3/4. Describe other parameters in ‘PUCCH-FormatConfig’ such as ‘interslotFrequencyHopping’, ‘pi2BPSK’, ‘simultaneousHARQ-ACK-CSI’, and ‘maxCodeRate’ are not applicable for format 0.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035631)[Proposal 30 Apply the following updates for Row 4 to 11:](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035632)[· Change content of Column B to “Enhanced Type-3 HARQ-ACK CB”](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035633)[· Change “enhanced” and “enh.” to “reduced size” in Column J](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035634)[Proposal 31 Replace content of Column J of Row 12 with “Configure triggering of HARQ-ACK re-transmission on a PUCCH resource as described in Clause [x.x] in TS38.213”.](file:///C%3A%5CUsers%5Ckhugl%5CAppData%5CLocal%5CTemp%5C7zO0F6CBF9C%5CR1-2108829%20HARQ-ACK%20Enhancements%20for%20IIoT_URLLC.docx#_Toc84035635) |

### R1-2108840 Discussion on HARQ-ACK enhancements for eURLLC ZTE

***Observation 1:*** *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 2****: Dividing SLIV group based on per slot can still work when UL sub-slot crossing 2 DL slots boundary.*

***Proposal 1:*** *It should firstly be clarified whether the PUCCH corresponding to the SPS PDSCH and the PUCCH of the SPS HARQ-ACK deferral are dynamic PUCCH or semi-static PUCCH.*

***Proposal 2:*** *Support joint operation of SPS HARQ-ACK deferral and semi-static PUCCH carrier switching.*

***Proposal 3:*** *If the HARQ-ACK feedback for a PDSCH is performed with SPS HARQ-ACK deferral, and if a Type-1 codebook contains the PDSCH, NACK information is generated for the PDSCH in initial HARQ bits in the Type-1 codebook.*

***Proposal 4:*** *Support sub-slot SR /CSI PUCCH repetition.*

***Proposal 5:*** *The cancelled HARQ-ACK codebook should be triggered for retransmission as early as possible after the conflict is determined, for example, the earliest trigger starts after the decoding of PDCCH corresponding to the high-priority PUCCH.*

***Proposal 6:*** *Support Alt. 1 to define the offset which indicates a PUCCH to be retransmitted.*

* *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*
* *The value of offset could be positive or negative.*

***Proposal 7:*** *Support the introduction of a size field in the trigger DCI to indicate the size for HARQ-ACK codebook in the PUCCH to be retransmitted.*

***Proposal 8:*** *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 9****: 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 10:*** *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 configured to allow PUCCH carrier switching.*

***Proposal 11:*** *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.*

***Proposal 12:*** *For PUCCH carrier switching based on dynamic indication, for the case of PCell PUCCH slot length longer than that of the dynamically indicated PUCCH cell slot,*

* *Alt. 3: UE expects that for supporting dynamic PUCCH carrier switching, PUCCH (including CSI, SR, HARQ-ACK, etc.) is always transmitted on one carrier at the duration of PCell slot.*

***Proposal 13:*** *For PUCCH carrier switching based on dynamic indication, for the case of PCell PUCCH slot length shorter than that of the dynamically indicated PUCCH cell slot,*

* *Alt. 3: UE expects that for supporting dynamic PUCCH carrier switching, PUCCH (including CSI, SR, HARQ-ACK, etc.) is always transmitted on one carrier at the duration of indicated PUCCH cell slot.*

***Proposal 14:*** *UE does not expect overlapping PUCCH slots with semi-static time domain PUCCH cell indication on more than one carrier, i.e. gNB should only configure a single PUCCH cell for a final PUCCH slot.*

***Proposal 15:*** *For PUCCH carrier switching based on semi-static patterns, when slot length of the time-domain pattern is shorter than the PUCCH cell slot, UE does not expect overlapping PUCCH slots with semi-static time domain PUCCH cell indication on more than one carrier, i.e. gNB should only configure a single PUCCH cell for a final PUCCH slot.*

***Proposal 16:*** *For PUCCH carrier switching based on semi-static patterns, when slot length of the time-domain pattern is longer than the PUCCH cell slot, UE does not expect overlapping PUCCH slots with semi-static time domain PUCCH cell indication on more than one carrier, i.e. gNB should only configure a single PUCCH cell for a final PUCCH slot.*

***Proposal 17:*** *For PUCCH carrier switching based on semi-static patterns, when slot length of the time-domain pattern is longer than the PUCCH cell slot, UE expects that for supporting semi-static PUCCH carrier switching, by a signalling to be used to indicate the specific PUCCH slot among more than one candidates within the reference slot duration.*

***Proposal 18:*** *The maximum number of carriers supporting PUCCH carrier switching is 4.*

### R1-2108906 Discussion on HARQ-ACK feedback enhancements for Rel-17 URLLC Spreadtrum Communications

1. ***For SPS HARQ-ACK deferral, the maximum deferral value in terms of k1+k1def is the latest PUCCH starting slot, no matter with actual PUCCH repetition number.***
2. ***Do not support the joint operation of SPS HARQ-ACK deferral and PUCCH carrier switching in Rel-17.***
3. ***UE capability signalling to report X (equal or smaller than 3) maximum number of supported simultaneously configured CBs that can be dynamically indicated***
4. ***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)***
5. ***For Rel-17 one-shot triggering, Alt. 3 is supported:***
* ***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.***
1. ***On the definition of some ‘PUCCH slot offset’ for dynamically indicating the HARQ-ACK codebook(s) / PUCCH occasions to be re-transmitted:***
* ***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)***

### R1-2108966 HARQ-ACK enhancements for Rel-17 URLLC vivo

Proposal 1: For determining when to defer from the initial slot/sub-slot, only potential HARQ-ACK multiplexing is considered, and potential multiplexing between/among HARQ-ACK and other UCI type(s) is not considered.

Proposal 2: If it is determined not to defer the SPS HARQ-ACK, legacy UCI multiplexing/prioritization rules should be reused to determine the final PUCCH/PUSCH transmission, as well as the conveyed UCI(s).

Proposal 3: After the target slot/sub-slot is determined, legacy UCI multiplexing/prioritization rules should be reused in the target slot/sub-slot to determine the final PUCCH/PUSCH transmission, as well as the conveyed UCI(s).

Proposal 4: Enhanced Type-3 codebook may contain HARQ-ACK of HARQ processes configured for one or more concerned SPS configurations.

Proposal 5: For triggering an enhanced Type-3 codebook, support Option 2, i.e., there is a 1-bit triggering DCI field to indicate whether an enhanced Type-3 codebook is triggered or not by the DCI, and if it indicates triggered and more than one enhanced Type-3 codebook is configured (i.e., M > 1), the DCI does not schedule a PDSCH and some unused field(s) in the DCI is reused/re-interpreted to indicate which enhanced Type-3 codebook is triggered actually.

Proposal 6: Regarding the triggering signaling for one-shot triggering of HARQ-ACK re-transmission, support Alt. 3, i.e., there is a 1-bit DCI field to indicate whether one-shot triggering of HARQ-ACK re-transmission is triggered or not by the DCI, and if it indicates triggered, the DCI does not schedule a PDSCH and some unused field(s) in the DCI is reused/re-interpreted to indicate the HARQ-ACK codebook / PUCCH occasion to be re-transmitted.

Proposal 7: For indicating the PUCCH slot offset for one-shot triggering of HARQ-ACK re-transmission, support Alt. 2, i.e., 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.

Proposal 8: New or initial HARQ-ACK to be reported in the same PUCCH slot, if any, is appended to the HARQ-ACK codebook triggered for re-transmission.

Proposal 9: Support the re-transmission of cancelled HARQ-ACK by enhanced Type-2 codebook.

Proposal 10: It can be clarified that for enhanced Type-2 codebook, PDSCH grouping is performed for each physical priority respectively, and at most two PDSCH groups are allowed per physical priority.

Proposal 11: Support sub-slot based PUCCH repetition configured with / using nrofSlots also for other UCI types, including SR and CSI.

Proposal 12: The maximum number of carriers supported for PUCCH carrier switching is two.

Proposal 13: For PUCCH carrier switching based on dynamic indication, HARQ-ACK without dynamic indication, including SPS HARQ-ACK and/or HARQ-ACK for the PDSCH scheduled by a DCI without the PUCCH cell indication field, may be multiplexed with DG HARQ-ACK corresponding to non-fallback DCI into a same HARQ-ACK codebook due to overlapping, then the HARQ-ACK codebook is transmitted on the target PUCCH cell indicated for the DG HARQ-ACK.

Proposal 14: For PUCCH carrier switching based on dynamic indication, SPS HARQ-ACK may be transmitted on the target PUCCH cell indicated by the activation/release DCI, or, always transmitted on the PCell/PSCell/PUCCH SCell, when multiplexing with DG HARQ-ACK corresponding to non-fallback DCI is not applicable.

Proposal 15: For PUCCH carrier switching based on dynamic indication, HARQ-ACK for the PDSCH scheduled by a DCI without the PUCCH cell indication field may be always transmitted on the PCell/PSCell/PUCCH SCelll, when multiplexing with DG HARQ-ACK corresponding to non-fallback DCI is not applicable.

Proposal 16: For PUCCH carrier switching based on dynamic indication, HARQ-ACK without dynamic indication (including SPS HARQ-ACK and/or HARQ-ACK for the PDSCH scheduled by a DCI without the PUCCH cell indication field ), SR or CSI may be configured or indicated to be transmitted on same or different PUCCH cell(s).

Proposal 17: Multiplexing/prioritization mechanism(s) in Rel-15/16 can be extended so that UCIs coming from same/different cell(s) and overlapping in time domain can be multiplexed or prioritized by reusing legacy rules.

Proposal 18: For semi-static PUCCH carrier switching, the reference cell is an RRC configured PUCCH cell having the smallest SCS among PUCCH cells.

Proposal 19: For semi-static PUCCH carrier switching, the K1 set for the reference cell is used to construct a Type-1 codebook.

Proposal 20: For semi-static PUCCH carrier switching, same K1 set can be configured for each PUCCH cell in a PUCCH cell group.

Proposal 21: RAN1 determines to introduce separate RRC parameters, including pdsch-HARQ-ACK-OneShotFeedbackCBGDCI-1-2 and pdsch-HARQ-ACK-OneShotFeedbackNDIDCI-1-2, to control the content or structure of a Rel-16 Type-3 codebook triggered by a DCI format 1\_2 independently, or clarifies that these RRC parameters for DCI format 1\_2 reuse the corresponding one defined currently for DCI format 1\_1.

### R1-2109093 HARQ-ACK enhancements for Rel-17 URLLC/IIoT OPPO

***Proposal 1: 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*** ***corresponding to the maximum deferral value,***

* ***if the last PUCCH occasion is no later than slot/subslot*** ***corresponding to the maximum deferral value, a UE transmits the PUCCH as Rel-15/16;***
* ***otherwise,*** ***the UE transmits the PUCCH repetition(s) no later than slot/subslot corresponding to the maximum deferral value and cancels the PUCCH repetition(s) after slot/subslot corresponding to the maximum deferral value.***

***Proposal 2: If the deferred SPS HARQ-ACK is not transmitted in the target PUCCH slot, the deferred SPS HARQ-ACK can be triggered for one-shot HARQ-ACK retransmission.***

* ***The whole HARQ-ACK codebook is retransmitted without dropping the HARQ-ACK bits that exceed the maximum deferral timing.***

***Proposal 3:*** ***One-shot HARQ-ACK retransmission can be triggered in the slot used to determine the target PUCCH slot for SPS HARQ-ACK deferral.***

***Proposal 4: For an enhanced Type 3 HARQ-ACK CB triggered in a PUCCH slot, the UE is not expecting HARQ-ACK information in a Type 1 or Type 2 HARQ-ACK CB with the same priority index as the enhanced Type3 HARQ-ACK CB to be transmitted that cannot be mapped to the enhanced Type 3 HARQ-ACK CB.***

***Proposal 5: For enhanced Type 3 HARQ-ACK CB, the subsets of serving cells or HARQ processes triggered by DCI format 1\_1 and DCI format 1\_2 should be separately configured.***

***Proposal 6: CBG-based HARQ-ACK feedback can be configured for enhanced Type 3 HARQ-ACK CB.***

***Proposal 7: NDI report in enhanced Type 3 HARQ-ACK CB can be configured for enhanced Type 3 HARQ-ACK CB.***

***Proposal 8: A DCI triggering enhanced Type 3 HARQ-ACK CB can also schedule PDSCH transmission.***

***Proposal 9: A N-bit DCI field is used for triggering enhanced Type 3 HARQ-ACK CB, and N is up to 2.***

***Proposal 10: If both one-shot triggering for HARQ-ACK retransmission and Rel-17 intra-UE multiplexing is configured, a PUCCH carrying both HP HARQ-ACK and LP HARQ-ACK cannot be triggered for one-shot retransmission.***

***Proposal 11: A UE doesn’t expect that an initial HARQ-ACK transmission and a one-shot HARQ-ACK retransmission with the same priority index are triggered in one slot.***

***Proposal 12: One-shot triggering for HARQ-ACK retransmission is no need to be configured with Type-3 or enhanced Type-3 HARQ-ACK CB simultaneously.***

***Proposal 13: A N-bit DCI field is used for triggering HARQ-ACK retransmission, and N is up to 2.***

***Proposal 14: The PUCCH slot offset defines the offset between the triggering DCI and the PUCCH slot of the HARQ-ACK codebook to be re-transmitted.***

### R1-2109131 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:**

* *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 4:**

* *Further study the impact of dynamic requested HARQ-ACK retransmission on current DRX mechanism.*

**Proposal 5:**

* *Supporting joint operation of dynamic and semi-static carrier switching for a UE is slightly preferred.*

 **Proposal 6:**

* *For semi-static PUCCH carrier switching, further study how to determine the slots/sub-slots and target cell for PUCCH repetition transmissions.*

**Proposal 7:**

* *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 8:**

* *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.*

### R1-2109159 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: If both SPS HARQ-ACK deferral and PUCCH repetition are configured, if the first PUCCH occasion is no later than (sub-)slot *n*+*k1max*, the UE transmits the configured number of PUCCH repetitions starting from the target slot as per Rel-16 procedure.**

***Observation 2.1: Joint operation of SPS HARQ-ACK deferral and dynamic PUCCH carrier indication could be supported without any needed additional enhancements.***

***Observation 2.2: Joint operation of SPS HARQ-ACK deferral and PUCCH carrier switching based on semi-static configuration could be supported without any needed additional enhancements.***

The discussions **in Sec. 3 on PUCCH repetition enhancements** can be summarized in the following related observations and proposals:

**Proposal 3.1: RAN1 to agree (or conclude) to adopt the following decisions from Cov. Enh. WI for slot based PUCCH repetition also for sub-slot based PUCCH repetition:**

* ***For a PUCCH resource, if both a new repetition parameter corresponding to Rel-17 dynamic PUCCH repetition factor indication and the Rel-15/16 nrofSlots are configured, the new repetition parameter overrides nrofSlots.***
* ***In Rel-17, reuse the Rel-16 PUCCH repetition factors 2, 4, 8.***
* ***Dynamic PUCCH repetition factor indication for SR or P/SP-CSI on PUCCH is not supported in Rel-17.***

**Proposal 3.2: 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.**

* **For SR and P/SP-CSI, the starting symbol index within the slot of the related PUCCH config defines the start of the repetition bundle (i.e. the starting PUCCH sub-slot) as well as the starting symbol with respect to that sub-slot boundary.**

**Proposal 3.3: Support** ***inter-slotFrequencyHopping* for PUCCH repetition operation of PUCCH Format 0 and Format 2.**

***Observation 3.1: There seems to be no need to define some X-symbol or Y-sub-slot gap for transition period handling.***

**Proposal 3.4: 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 in Rel-17, the TDRA pruning/grouping is performed per DL slot after TDRA determination per sub-slot.**

* ***Note: This operation is logically nicely captured by the steps described by Huawei/HiSi in R1-2106490 and ZTE in R1-2106734.***

The discussions **in Sec. 5 on retransmissions of dropped HARQ-ACK** can be summarized in the following related observations and proposals:

**Proposal 5.1: X= 16 is the maximum number of enhanced Type 3 CBs that the specification supports, assuming that a DCI field is reused for indicating a CB.**

**Proposal 5.2: Agree the following change to the RAN1#106-e agreement on the enhanced Type 3 CB of smaller size:**

*Agreement from RAN1#106-e*

*The following enhanced Type 3 CB types of smaller size are supported, the CB to contain ~~either:~~*

* *~~the HARQ processes of a subset of configured CCs, or~~*
* *a subset of configured HARQ processes (specific to CCs)*

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

**Proposal 5.3: Agree the following change to the RAN1#106-e agreement on PHY priority handling of the enhanced Type 3 CB(s) of smaller size**

*Agreement*

*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, CBG and NDI use) irrespective of the PHY priority.*

**Proposal 5.4: Each of the enhanced Type 3 CBs is RRC configured with a pdsch-HARQ-ACK-OneShotFeedbackCBG and pdsch-HARQ-ACK-OneShotFeedbackNDI parameter.**

**Proposal 5.5: The timing reference for indicating the CB to be retransmitted is the PUCCH slot allocated for the retransmission by the one-shot retransmission triggering DL assignment.**

**Proposal 5.6: 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 appending 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 5.7: 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.**

**Proposal 5.8: If more than one enhanced Type 3 CB is configured, existing DCI field (e.g. modulation and coding scheme) is reused for enhanced Type 3 CB selection. When a triggering DCI also schedules PDSCH, only a fixed single RRC configured enhanced Type 3 CB (e.g. the one with the lowest index) can be triggered.**

**Proposal 5.9: With one-shot HARQ-ACK codebook re-transmission on PUCCH, the re-transmission triggering DCI does not schedule PDSCH, allowing maintaining DCI size by reusing a DCI field (e.g. modulation and coding scheme) for *slot\_offset* indication.**

**Proposal 5.10: Support joint configuration (and operation) of Rel-17 enhanced Type 3 CB and Rel-17 one-shot triggering of HARQ re-transmission reusing the Rel-16 one-shot CB request bit without additional overhead:**

**The one-shot CB request bit in DCI set to ‘1’ and the DCI scheduling PDSCH, triggers the enhanced Type 3 CB configured with the lowest index.**

**The one-shot CB request bit in DCI set to ‘1’ and the DCI not scheduling PDSCH / DL-SCH, one unused DCI field (such as e.g. the HARQ ID field) determines if either the enhanced Type 3 CB (e.g. bit(s) set to 0) or one-shot HARQ-ACK retransmission on PUCCH (e.g. bit(s) set to 1) is triggered.**

**For a triggered enhanced Type 3 CB, one other unused DCI field (such as the MCS field) is used to indicate which of the configured enhanced Type 3 CBs (from the list) is triggered.**

**For the one-shot HARQ-ACK retransmission on PUCCH, one other unused DCI field (such as the MCS field) is used to indicate the *slot\_offset* to determine the initial PUCCH slot of the HARQ-ACK codebook for re-transmission.**

**Proposal 5.11: Support one-shot triggering of HARQ-ACK retransmission 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.**

The discussions **in Sec. 6 on dynamic PUCCH carrier / cell switching** can be summarized in the following related observations and proposals:

**Proposal 6.1: RAN1 to focus on completing the PUCCH carrier switching feature in Rel-17 including the baseline SUL support of case 2-1 (i.e. either SUL or NUL of a cell can be configured with *PUCCH-config*). A feature extension also including the SUL operation with *PUCCH-config* on SUL and NUL of a serving cell (i.e. cases 2-2 and case 3) can be further considered after having the baseline feature support completed.**

**Proposal 6.2: The PUCCH carrier switching is limited to a maximum of one or three additional PUCCH cells (i.e. 2 or 4 PUCCH cells in total) according to UE capability indication.**

**Proposal 6.3: 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)**
* **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***

**Proposal 6.4: 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.**

**Proposal 6.5: 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 *pdsch-config*.**
* **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 *pdsch-config*.**

**Proposal 6.6: For PUCCH carrier switching based on dynamic indication and when the PCell PUCCH slot length is shorter than the dynamically indicated PUCCH cell slot, the UE does not expect the same UCI type (i.e. HARQ-ACK, SR or CSI) from more than one PCell PUCCH slot to be overlapping with a single dynamically indicated PUCCH cell slot**

**Proposal 6.7: For PUCCH carrier switching based on dynamic indication, if UE is indicated with more than one (non-overlapping) PUCCH slots on one or more PUCCH cells overlapping with a single PCell/PSCell PUCCH slot, UCI from PCell/PSCell PUCCH slot is multiplexed on the first of the indicated PUCCH slots.**

**Proposal 6.8: 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 6.9: For PUCCH carrier switching based on dynamic indication, the Type 2 CB DAI mechanism applies to the overall Type 2 CB to be transmitted on the target PUCCH cell including the HARQ-ACK on PUCCH on PCell to be multiplexed on the target PUCCH cell.**

**Proposal 6.10: For PUCCH carrier switching based on dynamic indication, the PUCCH carrier indication in an activation DCI applies to both the first and later SPS PDSCH HARQ-ACKs (without associated DCI).**

* **For SPS, the carrier indication is considered ‘dynamic’ only for the first HARQ-ACK, i.e. the carrier indication in the activation DCI, when applied for later SPS HARQ-ACKs, does not force to indicate the same cell/carrier for HARQ-ACK of dynamically scheduled PDSCH to the slots with SPS HARQ-ACK.**

**Proposal 6.11: Dynamic target carrier indication based on DCI applies also to HARQ-ACK corresponding to SCell dormancy indication.**

**Proposal 6.12: 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 6.13: 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 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 time-domain pattern is applied periodically**
	+ ***FFS on period / pattern length (e.g. 10ms, RRC configured,…).***
* **The pattern defines for each slot of the reference cell at least the applicable PUCCH cell**

**Proposal 6.14: 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.**

**Proposal 6.15: The reference cell is PCell/PSCell and no notation of reference cell is needed in the specification.**

**Proposal 6.16: 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 6.17:** **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 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.**

***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.***

### R1-2109215 UE feedback enhancements for HARQ-ACK CATT

***Proposal 1: Multiplexing with CSI/SR/PUSCH should be performed before SPS HARQ-ACK deferral.***

***Proposal 2: The first slot/sub-slot of PUCCH repetition is used to determine whether SPS HARQ-ACK bits exceed the maximum deferral time limitation, and the deferred SPS HARQ-ACKs bits which do not exceed the maximum deferral time limitation in the first slot/sub-slot of PUCCH repetition would be transmitted in all the slots/sub-slots of PUCCH repetitions.***

***Proposal 3: For one-shot triggering of dropped HARQ-ACK, the triggering DCI indicate the PUCCH slot offset between the slot for triggering DCI and the PUCCH slot of the HARQ-ACK codebook to be retransmitted.***

***Proposal 4: For one-shot triggering of dropped HARQ-ACK, 1-bit DCI field is included for explicit triggering indication. If the triggering DCI indicates ‘triggering’, the DCI does not schedule 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 retransmitted.***

***Proposal 5: For one-shot triggering of dropped HARQ-ACK, the retransmitted HARQ-ACK bits can be appended to the initial HARQ-ACK codebook.***

* ***FFS for enhancement of Type-1 codebook.***

***Proposal 6: The maximum number of cells for PUCCH carrier switching is two.***

***Proposal 7: Case 1, case 2-1 and case 3 are supported for PUCCH carrier switching if the maximum number of cells for PUCCH switching is two. Otherwise all the cases are supported.***

***Proposal 8: 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 SR and CSI are 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 is used as the reference slot.***

***Proposal 9: 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 10: 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 11: 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 12: 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 13: If joint operation of PUCCH carrier switching and SPS HARQ-ACK deferral is supported, it is preferred to perform PUCCH carrier switching first.***

***Proposal 14: Sub-slot based PUCCH repetition is supported for CSI and SR.***

***Proposal 15: For sub-slot based Type-1 HARQ-ACK codebook, the PDSCH TDRA grouping should be performed per DL slot.***

### R1-2109256 Discussion on some remaining issues for UE HARQ-ACK feedback enhancements China Telecom

**Observation: Expecting the total deferred and non-deferred HARQ-ACK bits can be accommodated in the determined target slot may lead to unbalanced HARQ-ACK load in UL slots and PUCCH resource waste.**

**Proposal 1: For SPS HARQ-ACK deferral, the target slot/sub-slot is determined for the HARQ-ACK bits based on the PDSCH ending timing order. When determining the target slot/sub-slot for deferred HARQ-ACK bit(s) corresponding to a PDSCH, if the number of total total deferred (with earlier PDSCH ending) and non-deferred UCI bits is larger than 2 on PUCCH format 0,1 resource, or the code rate on the PUCCH format 2,3,4 resource begins to be larger than the maximum code rate in a slot/sub-slot with valid PUCCH resource, the slot/sub-slot is not determined as target slot/sub-slot. Continue to check next slot/sub-slot with valid PUCCH resource if the maximum deferral time has not been met.**

**Proposal 2: For PUCCH carrier switching, the scenarios supported in Rel-17 include:**

* **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**

**Proposal 3: For dynamic indication of PUCCH carrier in DCI, if the bit width of the PDSCH-to-HARQ\_feedback timing indicator in DCI format 1\_1 or 1\_2, or the bit width of the PUCCH resource indicator in DCI format 1\_2 for one PUCCH carrier is not equal to the same field for another PUCCH carrier, a number of most significant bits with value set to '0' are inserted to smaller field until the bit width of the field for all the PUCCH carrier are the same.**

**Proposal 4: For the time-domain pattern configured for semi-static PUCCH carrier switching, the reference cell/carrier is the PUCCH cell/carrier having the smallest SCS among PUCCH cells/carriers.**

**Proposal 5: For PDSCH to HARQ-ACK offset k1 interpretation for semi-static PUCCH carrier switching, the reference cell/carrier is the PCell / PScell.**

### R1-2109277 Discussion on UE feeback enhancements for HARQ-ACK CMCC

***Proposal 1: on the maximum number of configured enhanced Type 3 HARQ CB, X = 4 or 8.***

***Proposal 2: No limitation on the number of PUCCH carriers or cells, for semi-static alternative.***

***Proposal 3: The maximum number of PUCCH carriers or cells is 4, for dynamic indication alternative.***

***Proposal 4: Periodicity of semi-static configuration is fixed to 10ms, for its simplicity and unity.***

***Proposal 5: The unit of the time pattern takes reference from the cell with the largest SCS.***

***Proposal 6: Regarding the carrier offset case, slot0 is aligned with Pcell/PScell.***

***Proposal 7: The corresponding slot number of other Scells is calculated according to slot offset configuration given by*** $N\_{slot, offset}^{CA}$ ***(TS38.211, 4.5 Carrier aggregation)***

### R1-2109342 UE feedback enhancements for HARQ-ACK CAICT

Proposal 1: Approve the proposals in the appendix which was discussed in the previous meeting.

Proposal 2: The maximum number of PUCCH cells per cell group is defined as X=2.

Proposal 3: For semi-static PUCCH carrier switching, the time-domain pattern configuration periodicity is fixed to 10ms.

Proposal 4: For semi-static PUCCH carrier switching, the reference cell corresponds to the lowest SCS of candidate cells. For the case the reference cell slot is longer than the target PUCCH cell slot, the first target PUCCH slot overlapping with the reference cell slot is used for UCI transmission.

Proposal 5: For HARQ-ACK codebook construction with dynamic PUCCH carrier switching, consider overlapped slots in other cells which includes SPS HARQ-ACK when constructs HARQ-ACK codebook in the target PUCCH cell.

Proposal 6: For HARQ-ACK codebook construction with semi-static PUCCH carrier switching, based on the reference slot and the numerology of reference cell rather than based on the actual slot and numerology of the target PUCCH cell.

### R1-2109354 UE feedback enhancements for HARQ-ACK TCL Communication Ltd.

**Proposal 1: Joint operation of SPS HARQ-ACK deferral and PUCCH carrier switching should be considered when each feature becomes complete.**

**Proposal 2: Regarding the dynamic selection of enhanced Type3 HARQ-ACK codebook, an N-bit DCI filed for triggering should be supported.**

**Proposal 3: For PUCCH carrier switching based on dynamic indication, if the PCell PUCCH slot length is longer than the dynamically indicated PUCCH cell slot, 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.**

**Proposal 4: For PUCCH carrier switching based on dynamic indication, the UE is not expected that UCI from more than one PCell PUCCH slot to be overlapping with a single dynamically indicated PUCCH cell slot.**

**Proposal 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.**

**Proposal 6: 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 first target PUCCH slot overlapping with the reference cell slot.**

**Proposal 7: For PUCCH carrier switching based on semi-static indication, the UE does not expect UCI from more than one reference cell slot to be overlapping with a single target PUCCH cell slot.**

### R1-2109406 UE feedback enhancements for HARQ-ACK Xiaomi

*Proposal 1: 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 2: The case of multiplexing and collision should not be considered on the switching PUCCH carrier.*

*Proposal 3:Out-of-order trigger and out-of-order HARQ feedback are not expected for PUCCH carrier switching.*

*Proposal 4: For joint operation of PUCCH carrier switching and SPS HARQ-ACK deferral, PUCCH carrier switching should be performed with high priority.*

*Proposal 5: SPS HARQ-ACK deferral should not be further performed on switched PUCCH carrier.*

*Proposal 6: one bit UL/SUL field in DCI 0\_1/0\_2 can be reused to indicate the PUCCH carrier switching.*

*Proposal 7: For the interaction of RRC configured PUCCH repetition and dynamic repetition indication, when dynamic repetition indication is available, ignore nrofSlots.*

*Proposal 8: For sub-slot based PUCCH repetition configured with dynamic indication, at least SR or P/SP-CSI on PUCCH is not supported.*

***Proposal 9: Support NACK skipping for skipped SPS PDSCH and support ACK skipping for non-skipped SPS PDSCH.***

***Proposal 10: Support using alt 4 HARQ bundling / compression combined with alt 1 and alt 3 together to achieve the most significant gain.***

### R1-2109482 On HARQ-ACK reporting enhancements Samsung

**Proposal 1: Rel-16 UCI multiplexing / PUCCH overriding rules are reused for deferred SPS HARQ-ACK in the initial slot, if applicable.**

**Proposal 2: If a SPS HARQ-ACK is multiplexed in another PUCCH or a PUSCH, the SPS HARQ-ACK cannot be deferred if the resulting PUCCH/PUSCH is scheduled by a PDCCH.**

* **FFS: The resulting PUCCH/PUSCH is not scheduled by a PDCCH.**

**Proposal 3: Simultaneous configuration of PUCCH repetition and Rel-17 SPS HARQ-ACK deferral is not supported.**

**Proposal 4: RRC configures N report states (HPNs, cell IDs) for a Type-3 HARQ-ACK CB, and**

1. **a One-Shot HARQ-ACK request field of ceil(log2(N) bits in DCI format 1\_1/1\_2 indicate one of the N report states.**
2. **a One-Shot HARQ-ACK request field of 1 bit in DCI format 1\_1/1\_2 with value 1 indicates no scheduled PDSCH and ceil(log2(N) bits from redundant fields indicate one of the N report states.**

**Proposal 5: For “one-shot triggered” HARQ-ACK CB**

1. **a One-Shot HARQ-ACK trigger field of ceil(log2(N) bits in DCI format 1\_1/1\_2 indicates one of previous N slots, relative to the slot of the DCI format 1\_1/1\_2 reception, for HARQ-ACK CB retransmission.**
2. **a One-Shot HARQ-ACK trigger field of 1 bit in DCI format 1\_1/1\_2 with value 1 indicates no scheduled PDSCH and ceil(log2(N) bits from redundant fields indicate one of previous N slots, relative to the slot of the DCI format 1\_1/1\_2 reception, for HARQ-ACK CB retransmission.**

**Proposal 6: For “one-shot triggered” HARQ-ACK CB, only slots with valid PUCCH resources are indicated.**

**Proposal 7: Support all UCI types for sub-slot based PUCCH repetition.**

**Proposal 8: Type-1 codebook for sub-slot based PUCCH supports PDSCH TDRA grouping per DL slot as in Rel-15/16.**

**Proposal 9: The maximum number of PUCCH cells is 2.**

**Proposal 10: The unit of the time pattern is the slot of the cell with the smaller SCS. The SCS of the P(S)Cell can also be considered if PUCCH cell switching when the P(S)Cell has larger SCS than the PUCCH SCell is not supported.**

**Proposal 11: 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 12: Multiplexing procedures for PUCCH transmissions on P(S)Cell and PUCCH SCell are not supported.**

**Proposal 13: Conditioned on no additional specification impact, 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 14: 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 15: Support PUCCH cell switching for all UCI types based on the cell timing pattern.**

**Proposal 16: A UE determines the PUCCH transmission power separately for the P(S)Cell and the PUCCH SCell. DCI format 2\_2 provides TPC commands for both cells.**

**Proposal 17: A UE is separately provided a pucch-Config for each BWP of the PUCCH SCell.**

**Proposal 18: Consider support for PUCCH carrier switching to include NUL/SUL after progressing the specifications for PUCCH cell switching and subject to minimum specification impact.**

**Proposal 19: 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 20: Remove duplicated HARQ-ACK information from the Type-1 HARQ-ACK codebook for intra slot PDSCH repetition.**

**Proposal 21: The HARQ-ACK timing indicator counts only slots with PUCCH resources.**

Additionally, the following are observed.

*Observation 1: Reusing Rel-16 UCI multiplexing / PUCCH overriding rules in the initial slot can help reduce the latency of SPS HARQ-ACK.*

*Observation 2: If a SPS HARQ-ACK PUCCH satisfies the deferral condition, the HARQ-ACK corresponding to a SPS PDSCH that cannot be deferred should be dropped.*

*Observation 3: In case of PUCCH repetition, PUCCH deferring mechanism based on semi-static configuration is already supported in Rel-16.*

*Observation 4: There is no need to additionally support for a Rel-17 Type-3 HARQ-ACK CB separate configuration of HARQ IDs / CCs per priority or SPS HARQ process IDs of specific priority only for a SPS HARQ-ACK only CB.*

*Observation 5: Separate configurations per priority of parameters for construction of HARQ-ACK CBs can be beneficial for all HARQ-ACK CB types.*

*Observation 6: Support of PUCCH cell switching in Rel-17 is conditioned on “aim for minimum specification impact”.*

*Observation 7: 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.*

### R1-2109575 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 for k1 interpretation is the target PUCCH cell.***
4. ***For PUCCH carrier switching based on semi-static PUCCH cell timing pattern, the granularity of the timing pattern is the slot of the reference cell, where the reference cell is configured to the UE.***
5. ***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.***
6. ***Both cases with PUCCH switching among different cells with some of the cell(s) configured with both NUL and SUL or also the case of PUCCH switching among NUL and SUL of a single cell are supported.***
7. ***Multiple carriers switching leading to the same initial carrier is allowed.***
8. ***If LP-PUCCH transmission is overlapping with HP-CG-PUSCH, the UE prioritizes the transmission of PUSCH and the gNB needs to re-schedule the PUCCH transmission on different or same carrier. For HP-PUCCH re-use Rel-16 prioritization rules.***
9. ***HARQ-ACK codebook per PUCCH carrier to be supported.***

### R1-2109604 Remaining issues of enhanced HARQ-ACK feedback procedures Intel Corporation

**Proposal 1-1**

* *For SPS HARQ-ACK deferral,*
	+ *If PUCCH is configured with repetitions, the deferral conditions are checked only for the initial PUCCH repetition*
	+ *If a PUCCH repetition could not be mapped to UL slot/sub-slot, the PUCCH repetition is not transmitted*
	+ *For overlap of repeated PUCCH, when one of UCIs contains SPS HARQ-ACK with enabled deferral, the UE can expect the first PUCCH and any of the second PUCCHs to start at a same slot and include a UCI type with same priority. One of these UCIs can be dropped.*

**Proposal 1-2**

* *For SPS HARQ-ACK deferral, support > 15 maximum bound for k1*

**Proposal 1-3**

* *Do not support joint operation of SPS HARQ-ACK deferral and dynamic PUCCH carrier switching for the case of different numerologies on switchable carriers*

**Proposal 2-1**

* *Support triggering of enhanced Type 3 CB transmission by DCI not scheduling other PDSCH*
	+ *“One-shot HARQ-ACK request” flag is reused, and whether it triggers Type3 or eType3 is configured by RRC*
	+ *The same condition on FDRA state is reused to indicate that DCI does not schedule PDSCH*
	+ *An unused field in DCI (e.g. MCS, HARQ ID, RV, etc) is utilized to indicate one of N RRC configured eType3 codebooks requested for retransmission*
* *Support triggering of enhanced Type 3 CB transmission by DCI scheduling PDSCH*
	+ *“One-shot HARQ-ACK request” flag is reused, and whether it triggers Type3 or eType3 is configured by RRC*
	+ *eType 3 CB is constructed according to the type provided by the first entry in RRC table for the dynamic eType3 CB type indication*

**Proposal 2-2**

* *For one-shot triggering of dropped HARQ-ACK retransmission, RAN1 to consider handling of situations when DCI(s) (including all DCIs) scheduling HARQ-ACK in the dropped PUCCH were missed, and the PUCCU is requested to be retransmitted.*

**Proposal 3-1**

* *For sub-slot-based Type 1 CB,*
	+ *Support TDRA pruning/grouping per DL slot after TDRA determination per UL sub-slot*

**Proposal 4-1**

* *RAN1 to consider the following*
	+ *Alt. 1*
		- *Introduce frequency hopping between sub-slot PUCCH repetitions*
		- *For sub-slot PUCCH repetition, introduce a mechanism of skipping UL symbols during repetitions mapping, e.g., by a configurable X-symbol gap*
	+ *Alt. 2*
		- *Do not support frequency hopping between sub-slot PUCCH repetitions*

**Proposal 4-2**

* *If multiplexing of a repeated PUCCH on PUSCH is supported, 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 4-3**

* *For sub-slot PUCCH repetition, the following values for the number of PUCCH repetition are defined in specification*
	+ *2, 4, 6, 7, 8*

**Proposal 5-1**

* *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 5-2**

* *For dynamic PUCCH carrier indication in DCI, limit the UCI information for switching to HARQ-ACK and SR (when multiplexed with HARQ-ACK)*

**Proposal 5-3**

* *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*

### R1-2109671 Discussion on HARQ-ACK feedback enhancements for Rel.17 URLLC NTT DOCOMO, INC.

**Proposal 1: For ordering deferred SPS HARQ-ACK bits from more than one ‘initial PUCCH slot’, 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 2: SPS HARQ-ACK deferring is only applicable for SPS HARQ-ACK bits from “initial PUCCH” without more than one repetitions.**

**Proposal 3: Joint operation of SPS HARQ-ACK deferring and PUCCH carrier switching is not supported.**

**Proposal 4: If multiple enhanced type 3 HARQ-ACK CBs are configured, the triggering DCI can’t schedule PDSCH. Dynamic selection among multiple configured enhanced type 3 HARQ-ACK CBs is indicated by unused fields (e.g. TDRA, FDRA, HPN, etc.).**

**Proposal 5: Deferred SPS HARQ-ACK bits from initial PUCCH slots before reporting slot of enhanced type 3 HARQ-ACK CB with smaller CB size will be dropped.**

**Proposal 6: For one-shot triggering of HARQ-ACK retransmission,**

* **The** **one-shot triggering DCI can’t schedule any PDSCH.**
* **If PUCCH carrier switching is not enabled, slot offset of the “old HARQ-ACK CB” relative to triggering DCI is indicated by some unused DCI fields (e.g. TDRA, FDRA, HPN, etc.). The slot offset is interpretated based on the numerology of the PUCCH reporting cell.**
* **If PUCCH carrier switching is enabled,** **PUCCH cell/carrier index of the “old HARQ-ACK CB” needs to be explicitly or implicitly indicated. Slot offset is interpretated based on the numerology of the PUCCH cell/carrier of the “old HARQ-ACK CB”.**

**Proposal 7: UE can transmit HARQ-ACK information of initial type 1/2 HARQ-ACK CB with the same PHY priority in the same PUCCH slot as one-shot triggered new retransmission. For generation of multiplexed HARQ-ACK CB, simply appending the initial type 1/2 HARQ-ACK and retransmitted HARQ-ACK bits can be applied.**

**Proposal 8: For interaction of SPS HARQ-ACK deferring and one-shot triggering of HARQ-ACK retransmission,**

* **one-shot triggered new retransmission should not impact deferring for SPS HARQ-ACK bits with different PHY priority from the priority indicated by the triggering DCI.**
* **deferred SPS HARQ-ACK bits with same PHY priority from initial PUCCH slots and before the new reransmission PUCCH slot will be dropped.**

**Proposal 9: It is not expected that (enhanced) type 3 HARQ-ACK CB is scheduled to be transmitted in the same PUCCH slot as the one-shot triggered new retransmission PUCCH.**

**Proposal 10: Only initial HARQ-ACK bits in the indicated “old HARQ-ACK CB” will be retransmitted in the new retransmission PUCCH triggered by one-shot triggering DCI.**

**Proposal 11: Do not support sub-slot based PUCCH repetition for SR and CSI.**

**Proposal 12: Do not support dynamic switching between slot and sub-slot based PUCCH repetition.**

**Proposal 13: RAN1 should complete the design of PUCCH carrier switching for Case 1 and Case 2-1 without relying on the outcome of discussion whether and/or how Case 2-2 and Case 3 are supported.**

**Proposal 14: For semi-static PUCCH carrier switching,**

* **the PUCCH cell timing pattern is defined based on the numerology of PCell/PScell/PUCCH-Scell.**
* **K1 is interpretated based on the numerology of PCell/PScell/PUCCH-Scell.**

**Proposal 15: 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.**

**Proposal 16: For PUCCH without dynamic PUCCH cell indication, multiplexing with PUCCH with dynamic cell indication is performed before applying semi-static PUCCH carrier switching. The multiplexed UCIs are transmitted on the cell of the PUCCH with dynamic cell indication.**

**Proposal 17: To multiplex HARQ-ACK on Pcell/Pscell/PUCCH-Scell and HARQ-ACK on DCI indicated PUCCH cell,**

* **type 2 HARQ-ACK CB is based on DAI counter based on the overall multiplexed HARQ-CK CB.**
* **type 1 HARQ-ACK CB is based extended candidate PDSCH slot set which is the union of candidate PDSCH slot set for the reporting slot (on the DCI indicated PUCCH cell) and candidate PDSCH slot set for overlapping slot on Pcell/Pscell/PUCCH-Scell,**
	+ **where candidate PDSCH slot set for the reporting slot (on the DCI indicated PUCCH cell) only considers K1 set con-figured for the DCI format(s) which are enabled for dynamic PUCCH cell indication.**

**Proposal 18: UE doesn’t expect:**

* **multiple HARQ-ACK slots on Pcell/Pscell/PUCCH-Scell overlaps with the same HARQ-ACK slot on the DCI indicated PUCCH cell.**
* **one HARQ-ACK slot on Pcell/Pscell/PUCCH-Scell overlaps with multiple HARQ-ACK slots on the same indicated PUCCH cell.**
* **one HARQ-ACK slot on Pcell/Pscell/PUCCH-Scell overlaps with multiple HARQ-ACK slots on the different indicated PUCCH cells.**

**Proposal 19: PUCCH repetition factor is determined based on the PUCCH resource on the target PUCCH cell after PUCCH carrier switching.**

**Proposal 20: If semi-static PUCCH carrier switching is enabled, a PUCCH repetition mapping to a different target PUCCH cell from the PUCCH cell of the first PUCCH repetition will be dropped.**

### R1-2109782 Considerations on HARQ-ACK enhancements for URLLC Sony

**Observation 1: The target PUCCH may be overloaded due to accumulation of dropped SPS HARQ-ACKs from multiple initial PUCCHs.**

**Observation 2: When the target PUCCH is overloaded, dropping deferred and non-deferred HARQ-ACKs due to dropping the target PUCCH as in Alt. 1 or dropping of only SPS HARQ-ACKs as in Alt. 3, would lead to the HARQ-ACK feedback performance to be worse than that of Rel-16.**

**Observation 3: Since SPS HARQ-ACK deferral is agreed to be supported because it is difficult for gNB to predict whether a PUCCH will be dropped due to changes to the TDD slot format, leaving it up to gNB to avoid overloading of PUCCH as suggested in Alt. 4 may therefore be difficult for the gNB.**

**Observation 4: HARQ-ACK CB construction for multiple SPS is NOT a function of the SPS’s HARQ Process Number (HPN) but rather it is a function of the LOCATION of the SPS. Hence the HARQ-ACK CB for multiple SPS is perfectly capable of transmitting HARQ-ACK corresponding to the same HPN.**

**Observation 5: The SPS PDSCH is most likely to be decoded correctly and dropping the corresponding HARQ-ACK would lead to unnecessary PDSCH retransmissions.**

**Observation 6: For the dynamic indication of one of *MCB* e-Type 3 CBs, introducing a new DCI field to indicate one of *MCB* + “no e-Type 3 CB trigger”, i.e. Option 1, would lead to larger DCI overhead, which may impact the PDCCH reliability.**

**Observation 7: Reinterpreting PDSCH scheduling fields in a DL Grant for indicating one of *MCB* e-Type 3 CBs, where *MCB*>1, would lead to doubling the DCI overhead and increases latency in scheduling PDSCH, since gNB needs to transmit another DL Grant to schedule the PDSCH.**

**Observation 8: 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 9: 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 10: The 1st PUCCH repetition has the highest importance compared to subsequent repetitions of the same PUCCH.**

We therefore propose the following:

**Proposal 1: When the target PUCCH is overloaded, part of the deferred HARQ-ACK bits are transmitted, which are selected from the *NHARQ* deferred HARQ-ACKs corresponding to the latest SPS.**

**Proposal 2: When the softbits of an SPS PDSCH corresponding to a deferred HARQ-ACK are dropped due to HARQ Process Number collision, the UE still transmits the deferred HARQ-ACK in the target PUCCH.**

**Proposal 3: When the DL Grant triggers a 1-shot e-Type 3 CBs, reuse Rel-16 Type 3 CB mechanism to indicate whether a PDSCH is scheduled or not and if a PDSCH is scheduled, a default e-Type CB is used for HARQ-ACK retransmissions, i.e.:**

* **If FDRA is all “0s” or all “1s”, then a PDSCH is not scheduled and the fields used for PDSCH scheduling are reinterpreted to indicate one of *MCB* e-Type 3 CBs**
* **If FDRA is not all “0s” or all “1s”, then a PDSCH is scheduled and the UE uses a default e-Type 3 CB to retransmit the HARQ-ACKs. The default e-Type 3 CB can be RRC configured**

**Proposal 4: The target PUCCH offset reference point is the triggering DCI.**

**Proposal 5: The granularity of the target PUCCH offset *KReTx* follows the smallest *K*1 granularity of the configured HARQ-ACK PUCCHs.**

**Proposal 6: The DCI triggering the 1-shot ReTx CB also indicates the starting OFDM symbol relative to the indicated slot/sub-slot of the target PUCCH.**

**Proposal 7: 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.**

### R1-2109809 UE feedback enhancements for HARQ-ACK ETRI

**Proposal 1: If some deferred SPS has an overlapped HPN, then the HARQ-ACK is updated and reported.**

**Proposal 2: Each deferred HARQ sub-codebook can be appended based on the deferred number, or the deferred HARQ codebook can be generated as a whole.**

**Proposal 3: If being repeated, the PUCCH is transmitted within the latest effective time window in the HARQ codebook if applicable.**

**Proposal 4: Deferring HARQ-ACK bits are supported regardless of its configured priority index.**

Regarding Type-3 HARQ-ACK codebook,

**Proposal 5**: **The size of an enhanced Type-3 HARQ-ACK codebook can be determined by at least activation/release DCI for SPS.**

**Proposal 6**: **The size of an enhanced Type-3 HARQ-ACK codebook can be determined by at least activated serving cells.**

**Proposal 7**: **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 8**: **The *pdsch-HARQ-ACK-enhType3NDI* may not needed for URLLC operations**.

**Proposal 9**: **The *pdsch-HARQ-ACK-enhType3CBG* may not needed for URLLC operations**.

Regarding HARQ-ACK retransmissions,

**Proposal 10: The dropped HARQ codebook can be appended to the initial HARQ codebook.**

**Proposal 11: Regardless of priority index, HARQ-ACK can be retransmitted.**

**Proposal 12: As a capability, the maximum time window or the maximum number for keeping HARQ codebooks can be reported.**

**Proposal 13: The retransmitting HARQ codebook can consist of only valid HARQ-ACK bits.**

Regarding PUCCH carrier switching,

**Proposal 14: SPS HARQ-ACK deferral may not be configured if PUCCH cell switching is enabled at least for different numerology.**

**Proposal 15: The maximum number of PUCCH cell can be the number of configured serving cells.**

**Proposal 16: Changing a serving cell for PUCCH transmission with repetition may have the same numerology between serving cells if supported.**

### R1-2109821 Discussion on UE feedback enhancements for HARQ-ACK Panasonic

**Proposal 1: The UE defers the SPS HARQ-ACK to a PUCCH with a repetition if all the repetitions are within the deferral period, i.e., k1+k1def. Otherwise, the UE does not use the deferred period.**

**Proposal 2: The PUCCH repetition should be performed over a single carrier even when the PUCCH carrier switching is enabled dynamically or semi-statically.**

**Proposal 3: The deferral periods and the number of performed PUCCH repetitions should be considered as a priority for handling the PUCCH collisions.**

**Proposal 4: The UE should be configured with sps-PUCCH-AN-List-r16 or n1PUCCH-AN PUCCH for each PUCCH carrier.**

**Proposal 5: 1-bit triggering DCI field (as for Rel.16 Type-3 codebook) is supported for the enhanced Type 3 HARQ-ACK codebook.**

* **If a single enhanced Type-3 codebook is configured (M=1), the triggering DCI can schedule also a PDSCH.**
* **If more than one enhanced Type-3 codebooks are configured (M>1), and DCI field indicates the triggering, the DCI cannot be used for scheduled PDSCH and some unused field is used to indicate the enhanced Type 3 codebook to be triggered.**

**Proposal 6: For one-shot triggering of HARQ-ACK retransmission on a PUCCH, 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 retransmitted.**

**Proposal 7: 1-bit DCI field is used to support the explicit triggering indication for one-shot triggering of HARQ-ACK retransmission on a PUCCH.**

* **If the triggering DCI indicates “triggering”, the DCI does not schedule PDSCH at the same time and some DCI field is used for the dynamic indication of the HARQ-ACK codebook / PUCCH occasion to be retransmitted.**

**Proposal 8: The specification supports 4 and 2 carriers for PUCCH carrier switching. 4 or 2 is up to UE capability selection.**

**Proposal 9: For dynamic PUCCH carrier switching, the target carrier can be derived from the PRI field. To enlarge PRI field should be considered.**

**Proposal 10: Define additional slot offset values among the PUCCH carriers.**

**Proposal 11: To enable dynamic and semi-static PUCCH carrier switching schemes simultaneously, the dynamic DCI overrides the semi-static configurations.**

### R1-2109822 Discussion on UE feedback enhancements for HARQ-ACK FGI, Asia Pacific Telecom

Proposal 1 The SPS HARQ-ACK codebook for slot n includes a SPS HARQ-ACK bit for a SPS PDSCH if the SPS PDSCH is transmitted in slot m, m is larger than or equal to n-k1-k1def,max, and if the PUCCH resources configured by SPS-PUCCH-AN-List-r16 in slot m+k1 to slot n-1 collide with semi-static DL symbols, SSB, or CORESET#0.

Proposal 2 A SPS HARQ-ACK bit in a HARQ-ACK codebook is set to NACK for transmission in a slot if the SPS HARQ-ACK bit was reported before the slot.

Proposal 3 The number of CBG HARQ-ACK bits for a TB in the enhanced Type 3 HARQ-ACK codebook should be based on the maximum of the values indicated by maxCodeBlockGroupsPerTransportBlock in PDSCH-CodeBlockGroupTransmission associated with high priority and the maxCodeBlockGroupsPerTransportBlock in PDSCH-CodeBlockGroupTransmission associated with low priority when pdsch-HARQ-ACK-OneShotFeedbackCBG-r16 is configured.

Proposal 4 A slot offset is indicated by the triggering DCI for one-shot triggering for HARQ-ACK retransmission.

Proposal 5 For RRC configured PUCCH cell timing pattern, the reference cell is determined by a RRC parameter or the cell with the lowest SCS in a PUCCH cell group.

Proposal 6 The PUCCH cell timing pattern length and the periodicity of the pattern are based on the configured TDD-UL-DL-pattern.

Proposal 7 If mutiple PUCCH cell timing patterns can be configured, each PUCCH cell timing pattern can have an associated index and a duration to indicate how long the configrued pattern is applied.

Proposal 8 Either a configurable maximum number of PUCCH cells or not setting a limit on maximum number of PUCCH cells is preferred.

Proposal 9 The supported maximum number of PUCCH cells can be reported by a UE capability.

Proposal 10 How to handle misaligned PUCCH configuration from different PUCCH cells, for example, sub-slot configuration, priority indication of PUCCH, SPS PDSCH only HARQ-ACK, and PUCCH repetition should be specified.

Proposal 11 To handle misaligned PUCCH configuration, consider prohibiting some parameters in PUCCH-Config from being different or establishing some rules for PUCCH carrier switching.

Proposal 12 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.

Proposal 13 Expand the PUCCH spatial relation Activation/Deacitvation MAC CE to indicate *PUCCH-SpatialRelationInfo* for multiple cells or make some rules to ensure the *PUCCH-SpatialRelationInfo* is correctly indicated before switching PUCCH cell.

Proposal 14 For PUCCH carrier switching, ensure that a cell to transmit a PUCCH corresponding to the PDSCH providing *PUCCH-SpatialRelationInfo* is same as the cell indicated by the MAC CE.

### R1-2109893 HARQ enhancements for IIoT and URLLC InterDigital, Inc.

***Proposal 1:*** *The UE can be configured with more than one enhanced Type 3 HARQ CB.*

***Proposal 2:*** *For the case of more than one configured enhanced Type 3 CB, 1-bit is used to trigger the enhanced Type3 HARQ CB and the unused DCI fields of a non-scheduling DCI can indicate which one to be triggered.*

***Proposal 3:*** *1-bit DCI field is used to support triggering indication of Rel-17 one-shot HARQ re-transmission.*

***Proposal 4:*** *The UE expects the same PUCCH carrier indication for all the scheduled A/Ns associated with the same HARQ-ACK codebook.*

### R1-2109940 HARQ-ACK feedback enhancement for IIoT/URLLC Lenovo, Motorola Mobility

**Proposal 1: Timing information of a HARQ-ACK codebook/PUCCH occasion triggered for retransmission is defined in terms of a slot/sub-slot offset with respect to a DL slot where a DCI format triggering the retransmission is detected.**

**Proposal 2: Support implicit triggering of HARQ-ACK retransmission based on indication of two HARQ-ACK transmission occasions in DCI.**

**Proposal 3: 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.**

### R1-2109970 Discussion on UE feedback enhancement for HARQ-ACK LG Electronics

Observation: if PUCCH resource in a slot has repetition factor larger than 1, no HARQ-ACK deferral is triggered.

Proposal #1: for target PUCCH with K repetition in the target slot, maximum deferral value can be increased by K

Proposal #2: SPS HARQ-ACK deferral for a SPS configuration is enabled by configuring maximum deferral value in the SPS configuration.

Proposal #3: It is necessary to discuss whether entire HARQ-ACK codebook is deferred or a part of HARQ-ACK bits corresponding to multiple SPS configurations is deferred when SPS HARQ-ACK deferral is enabled for only part of the SPS configurations for a PUCCH.

Proposal #4: when multiple SPS HARQ-ACKs in different slots are deferred to a same target slot, deferred SPS HARQ-ACK codebooks are appended to the initial HARQ-ACK bits (originally to be transmitted in target slot) according to UL slot index of initial slots for each deferred SPS HARQ-ACK codebook.

Proposal #5: for determination of target PUCCH to validate target slot for a deferred PUCCH, UE assume no other deferred PUCCH exists.

Proposal #6: For joint operation between HARQ-ACK deferral and PUCCH carrier switching, UE should try PUCCH carrier switching first prior to SPS HARQ-ACK deferral procedure.

* FFS: the case where UL slot in the switched carrier is invalid for SPS HARQ-ACK PUCCH.

Proposal #7: For joint operation between SPS HARQ-ACK deferral and One-shot HARQ-ACK re-transmission, UE assume no SPS HARQ-ACK deferral for One-shot HARQ-ACK re-transmission. In other words, UE performs One-shot HARQ-ACK re-transmission as if no SPS HARQ-ACK deferral occurs.

Proposal #8: unified triggering method for both Type-3 HARQ-ACK codebook and One-shot HARQ-ACK re-transmission can be supported.

Proposal #9: No additional codebook types is necessary for enhanced Type-3 codebook.

Proposal #10: Slot offset indicator is introduced for One-shot HARQ-ACK re-transmission.

* The PUCCH resource scheduled by triggering DCI is the reference to indicate the slot offset.
* The unit of the slot offset is according to slot length (SCS) configuration for the PUCCH.

Proposal #11: Introduce additional RRC parameters to configure NDI reporting and CBG-level HARQ-ACK information per each of enhanced Type-3 codebooks.

Proposal #12: Prioritize Case 1 and 2-1 and deprioritize (or do not pursue) Case 2-2 for PUCCH carrier switching.

Proposal #13: For PUCCH carrier switching based on semi-static pattern, the PDSCH to HARQ-ACK offset k1 can be interpreted based on the numerology of a reference cell (i.e., primary cell).

Proposal #14: For PUCCH carrier switching based on semi-static pattern, in case when the slot in the reference cell corresponding to K1 overlaps with multiple slots in the switched carrier due to different SCS, the first overlapping slot in the switched carrier is determined to be used for PUCCH transmission in the switched carrier.

Proposal #15: It can be supported to configure a reference cell to determine HARQ-ACK timing in case with semi-static PUCCH carrier switching pattern.

Proposal #16: Use 3-bit PRI field or adopt dedicated DCI field to indicate switched carrier for PUCCH transmission.

**Proposal #17: For UE configured to use both dynamic and semi-static carrier switching, it is necessary to define which sets of HARQ-ACK timing values (configured for which cell) would be used for HARQ-ACK codebook construction**.

### R1-2110027 Rel-17 URLLC UE feedback enhancements for HARQ-ACK 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 3-3: nested PUCCH symbols are not allowed for PUCCH carrier switching.**

**Proposal 3-4: out-of-order HARQ-ACK remains forbidden for non-mTRP scenarios with PUCCH carrier switching.**

**Proposal 3-5: For semi-static PUCCH switching, the periodicity/offset for SR/CSI configurations and K1 for SPS HARQ-ACK are interpreted based on the reference cell numerology, which is used to determine the target PUCCH cell based on the semi-static time-domain pattern. The PUCCH resource ID for SR/CSI/SPS HARQ-ACK is interpreted based on the PUCCH configuration of the target PUCCH cell.**

* **FFS whether to configure different PUCCH resource ID for different target PUCCH cell**

**Proposal 3-6: For semi-static PUCCH switching, the reference cell is the one with the smallest SCS among the candidate PUCCH cells.**

### R1-2110178 HARQ-ACK enhancement for IOT and URLLC Qualcomm Incorporated

In summary, we make the following observations for HARQ-ACK feedback enhancement for Rel-17 IOT and URLLC.

***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 not be activated for UEs configured to monitor PDCCH for DCI 2\_0 (SFI).***

***Proposal 2: RAN 1 to discuss/clarify the SPS HARQ-ACK multiplexing onto PUSCH at “initial” slot – slot where SPS HARQ collision with DL happens.***

***Proposal 3: RAN 1 to discuss/clarify multiplexing of i) deferred SPS HARQ-ACK and ii) PUSCH at “target” slot.***

***Proposal 4: For SPS HARQ-ACK deferral, if the UE is configured with “simultaneousHARQ-ACK-CSI”, support multiplexing of:***

* ***Deferred SPS HARQ and***
* ***Non-aperiodic CSI***
* ***New HARQ (if any)***

***at the target slot, if PUCCH resource available for the whole UCI payload. PUCCH transmission takes place in a PUCCH resource from PUCCH-Resource-Set (if any), or PUCCH-CSI-ResourceList or multi-CSI-PUCCH-ResourceList.***

***Proposal 5: For SPS HARQ-ACK deferral, support multiplexing of:***

* ***Deferred SPS HARQ and***
* ***Aperiodic CSI and***
* ***New HARQ (if any)***

***at the target slot, if the whole UCI payload can be mapped onto the scheduled PUSCH.***

***Proposal 6:******Multiplexing of new HARQ bits - from new DG HARQ or new SPS HARQ - and deferred SPS HARQ of different PHY priorities is supported; the combined HARQ CB - new HARQ CB and appended SPS HARQ CB - is of high priority if at least one HARQ bit in the combined HARQ CB is of high priority.***

***Proposal 7:******For multiple SPS HARQ CBs deferral, appending of SPS HARQ CBs is done at the end of an existing new HARQ CB (if any) with the order of:***

1. ***Time of initial PUCCH transmission, hence slot of PUCCH having collided with DL or SSB or CORESET 0, i.e., earliest colliding with DL SPS HARQ CB is appended first***
2. ***Multiplexing of deferred SPS HARQ CBs of different priorities supported***
3. ***If there is at least 1 high priority HARQ bit in the overall HARQ CB, the whole/combined HARQ CB is of high priority.***

***Proposal 8:******With regards to modified proposal 2.4.1 of #106e, to be clarified what the term “maximum payload of PUCCH configurations” stands for. Is it:***

1. ***The maximum UCI payload size (maxPayloadSize among all configured PUCCH resource sets), i.e. 1706 bis, or***
2. ***The maximum UCI payload size that can be supported from the PUCCH resource at the current slot, which is roughly the product of:***
* ***Number of resource blocks***
* ***Number of OFDM symbols***
* ***coding rate.***

***Proposal 9:******If the UCI payload at target slot is consisted of both:***

* ***DG HARQ bits and***
* ***Deferred SPS HARQ and***
* ***the maximum payload that can be supported from a valid PUCCH resource at the current slot is less than the total UCI payload, then, this case is considered as error case; the UE drops the whole UCI payload (both DG HARQ and deferred SPS HARQ).***

***The maximum payload that can be supported from a valid PUCCH resource at the current slot is derived roughly from the product of:***

* ***Number of PRBs***
* ***Number of OFDM symbols***
* ***Coding rate***

***Same rule applies if at the target slot new SPS HARQ bits are present.***

***Proposal 10:******In case of SPS HARQ repetitions configuration, SPS HARQ deferral can be activated and the conclusion from #106e for normal (“non-deferred”) PUCCH repetition procedure should be applied:***

***“Conclusion: It is clarified that a PUCCH repetition in case (including the first PUCCH repetition) is postponed to the next available slot if the PUCCH repetition collides with SSB symbols or symbols indicated as DL by tdd-UL-DL-ConfigurationCommon or tdd-UL-DL-ConfigurationDedicated.***

***There is no consensus in RAN1 for whether or not the above case is supported in Rel-15 for the first PUCCH repetition when the PUCCH is triggered by DCI.”***

***Maximum deferral time is not modified, and it is applicable to the whole number of repetitions.***

***Upon each repetition transmission, UE checks if the available number of slots up to the maximum deferral time instant is higher than the number of remaining repetitions; in case the available number of slots up to maximum deferral instant is less than the number of remaining repetitions, the UE drops the remaining repetitions.***

***Proposal 11:******For SPS HARQ scheduled in flexible symbols and DG PDSCH allocation resulting in SPS HARQ collision – due to flexible symbols just turned into DL symbols in current slot, support multiplexing of***

***- deferred SPS HARQ-ACK and***

***- new DG HARQ bits
onto PUCCH indicated by DCI 1\_x. No attempt for the UE to find “1st available PUCCH resource” after SPS HARQ collision.***

***Proposal 12:******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”,***
* ***“PUCCH Carrier Switch” (in case of more than 1 PUCCH CCs),***
* ***“Rel. 17 Type 3 CB HARQ”, or***
* ***“Request triggered HARQ-ACK codebook retransmission”***
* ***Joint configuration of any of the above, whenever applicable.***

***Proposal 13:*** ***Upon joint configuration of any combination of “SPS HARQ deferral to 1st available PUCCH resource”, “PUCCH carrier switching”, “Rel. 17 Type 3 CB HARQ”, “Triggered request for HARQ Retransmission”, 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 (for SPS HARQ deferral to 1st available PUCCH resource), or***
* ***When a “PUCCH-carrier switch command” is received in DCI (in case of more than 1 PUCCH CCs and if dynamic PUCCH-carrier switching is activated), or***
* ***When a request for “Rel. 17 Type 3 HARQ CB” is received, or***
* ***When a DCI for “1-shot HARQ retransmission” is received, or***
* ***When the maximum value of “k1\_def” is reached.***

***Proposal 14: The Rel. 17 Type 3 HARQ triggering DCI 1\_x at least contains the following fields:***

***- The requested CC(s)***

***- The starting HARQ Process ID, #N, per requested CC***

***For a given Rel. 17 Type 3 HARQ CB size, equal to M, the reported HARQ Processes per CC are the HARQ Process IDs from #N up to the (#N + #M - 1).***

***Alternatively, the DCI 1\_X triggering the request for Rel. 17 Type 3 HARQ CB contains only the starting HARQ Process ID, #N, which is the same starting HARQ Process ID for all activated CC.***

***Proposal 15: The Rel. 17 Type 3 HARQ triggering DCI 1\_x can schedule PDSCH.***

***Proposal 16: For the “triggering HARQ-ACK CB re-transmission”:***

* ***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 17: The DCI triggering the request for the “triggered HARQ-ACK CB re-transmission” contains the indication of:***

***- The request for the “last” or “earliest” cancelled HARQ CB.***

***Proposal 18: Scheduling of new PDSCH and multiplexing with new HARQ bits is not allowed for “triggerd HARQ-ACK CB re-transmission.***

***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: Do not support the following two cases related to SUL for PUCCH switch.***

* ***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***

***Proposal 23: For semi-static configured PUCCH cell 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 cell 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 24: In PUCCH power control, support separate P0 configuration for each of the cells with PUCCH cell switch enabled.***

***Proposal 25: 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 26: Support to use MAC-CE to signal PUCCH spatial relation on Scell(s) with PUCCH cell switch. FFS details of such MAC-CE signalling including how to reduce the MAC-CE overhead.***

***Proposal 27: Support introducing a new PHR type, i.e., type 4 PHR, for PUCCH cell switch in NR Rel-17.***

***Proposal 28: for semi-static PUCCH carrier switch, if a Scell indicated in the time pattern is deactivated by MAC-CE, the Scell cell is fallback to Pcell in the time pattern.***

***Proposal 29: RAN1 to study then decide whether and how to support the following joint operations.***

* ***Joint operation of PUCCH cell switch, parallel PUCCH/PUSCH transmission, and intra-UE multiplexing.***
* ***Joint operation of PUCCH cell switch with PUCCH repetition.***
* ***Joint operation of PUCCH cell switch with SPS A/N deferral.***

***Proposal 30: 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*** $n\_{U}-K\_{1,k}$***, UE determines a set of TDRA candidates that ends in the UL sub-slot, and perform TDRA pruning within the group based on the Rel-15 approach.***

### R1-2110244 On the UE feedback enhancements for HARQ-ACK ITRI

**Proposal:**

Support following cases for PUCCH carrier switching:

* 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 3: PUCCH carrier switching for a single cell configured with SUL and having PUCCH configured for NUL and SUL

### R1-2110287 Discussion on PUCCH carrier switch for HARQ-ACK enhancement ASUSTeK

**Proposal 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 SCell dormancy indication in the DCI without scheduling PDSCH**
* **HARQ-ACK corresponding to the Rel-17 beam indication DCI for unified TCI without scheduling PDSCH**

**Proposal 2: For PUCCH repetition, repetition of PUCCH in different PUCCH carrier is not supported in Rel-17**

**Proposal 3: For a number of PUCCH repetitions** $N\_{PUCCH}^{repeat}$**, UE determines a PUCCH carrier for first PUCCH repetition**

* $N\_{PUCCH}^{repeat}-1$  **PUCCH repetitions are transmitted on the same PUCCH carrier**