3GPP TSG RAN WG1 #104e R1-210xxxx

e-Meeting, January 25th – February 5th, 2021

Source: Moderator (ZTE)

Title: Summary of AI 8.4.3 for HARQ for NTN

Agenda Item: 8.4.3

**Document for: Discussion and Decision**

# **Introduction**

In RAN1#102e and 103e meeting, progress on HARQ related issues have been achieved. In this meeting, companies’ views to refine the details and on other remaining issues are summarized with corresponding observations/proposals on following aspects with detailed proposals from each company listed in Appendix.

* Enhanced HARQ process ID indication
* HARQ codebook enhancements
* PDSCH/PUSCH scheduling restriction
* Restriction on HARQ feedback disabling
* Performance enhancements

# **Enhanced HARQ process ID indication**

In RAN1#103e, following agreement has been achieved:

Agreement:

* Enhanced HARQ process ID indication is supported for DCI 0-2/1-2 and DCI 0-1/1-1 by at least one of following:
	+ Option 1: Slot index as the MSB
	+ Option 1-a:Slot index as the LSB
	+ Option 2: Reusing one bit from other bit field
	+ Option 3: Extending the HARQ process ID field up to 5 bits
* FFS: DCI 0-0/1-0
* Note: 32 is taken as maximal supported HARQ processes number for both UL and DL

Then, in this meeting, ***views on following options from 25 companies are summarized as:***

* Option 1: Slot index as the MSB is supported by [OPPO, Huawei, Intel, Lenovo, Panasonic(2nd priority), Xiaomi, Qualcomm]
* Option 1-a: Slot index as the LSB is supported by [CATT, ZTE, Intel, Panasonic (2nd priority), Xiaomi].
* Option 2: Reusing one bit from other bit field is supported by [Huawei, CATT, ZTE, MTK, Spreadtrum, China Telecom, ETRI, Apple]. More specifically, w.r.t the applicability, at least following are highlighted:
	+ Applicable for DCI format:
		- DCI 0-0/1-0 [vivo, ZTE, Apple]
		- DCI 0-1/1-1 and 0-2/1-2 [ZTE]
* Option 3: Extending the HARQ process ID field up to 5 bits is supported by [CAICT, vivo, MTK, LG, Spreadtrum, China Telecom, Ericsson, APT, InterDigital, Panasonic(first priority), CMCC, Samsung, Nokia, Apple]. More specifically, w.r.t the applicability, at least following are highlighted:
	+ Applicable for DCI format:
		- DCI 0-2/1-2 [Ericsson]
		- DCI 0-1/1-1 and 0-2/1-2 [vivo, CAICT, LG, APT, Panasonic, CMCC, Nokia, Apple]
		- DCI 0-0/1-0 [CAICT, CMCC]
	+ Not applicable for DCI format:
		- DCI 0-0/1-0 [Ericsson, Panasonic]

Moreover, w.r.t DCI 0-0/1-0, [Nokia, Ericsson] highlight that one additional bit (as MSB) can be added for HARQ ID indication (only applicable for NTN). As default, 16 HARQ process number is assumed for DCI 0-0 and 8 is assumed for DCI 1-0 [CATT]. In addition, [Sony, Nokia, Intel, MTK] prefer to support only one option. [Ericsson] also highlights that the enhanced HARQ indication is used once the larger HARQ process number is configured via RRC signalling for both DL and UL.

According to the above summary, the following proposals are listed as majority views:

**[Initial Proposal 1]:**

Enhancement on the HARQ process indication is supported as:

* For DCI 0-2/1-2:
	+ Option 3: Extending the HARQ process ID field up to 5 bits
* For DCI 0-1/1-1 and 0-0/1-0, at least one of following is supported:
	+ Option 1: Slot index as the MSB
	+ Option 1-a:Slot index as the LSB
	+ Option 2: Reusing one bit from other bit field
	+ Option 3: Extending the HARQ process ID field up to 5 bits

Please provide your views below including preference for each DCI format and option.

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| --- | --- |
| **Company** | **Comments and Views** |
| Panasonic | We are not supportive for proposal 1 as it is. We are ok with DCI 0-2/1-2 and DCI 0\_1/1\_2. For DCI 0\_0/1\_0, it would not be desired to extend considering the fallback usage of DCI 0\_0/1\_0. No enhancement for DCI 0\_0/1\_0 should be listed as an option.  |
| OPPO | Fallback DCIWe think that it is risky to re-interpretation DCI field for fallback DCI 0-0/1-0 based on UE-specific RRC configuration. Any ambiguity will cause serious problem and this is not NR R15 design principle. Non-FB DCIIt is beneficial to have a unified design to minimize the specification load.  |

# **HARQ codebook enhancements**

In RAN1#103e, following agreement has been achieved:

Agreement:

HARQ codebook enhancement is supported as:

* For Type-2 HARQ codebook:
	+ Option-1: Reduce codebook size with:
		- HARQ-ACK codebook only includes HARQ-ACK of PDSCH with feedback-enabled HARQ processes
			* FFS: the details of C-DAI and T-DAI counting for DCI of PDSCH with feedback-enable/disabled HARQ processes
		- FFS: at least DCI for SPS release/SPS PDSCH
	+ Option-2: No enhancement
	+ Other options are not precluded.
* For Type-1 HARQ codebook, further discuss is needed with down selection among following options:
	+ Option-1: No enhancement;
	+ Option-2: Report NACK on disabled process
	+ Option-3: Reduce codebook size with criteria
* FFS: Enhancements for Type-3 HARQ codebook

Then, in this meeting, ***further views from 24 companies are summarized as:***

1. W.r.t the Type-1 Codebook (Semi-static codebook):
	* Option-1: ZTE, CATT, Intel, Lenovo, Panasonic, CMCC, Xiaomi, Nokia
	* Option-2: Ericsson
	* Option-3: Huawei, Sony, InterDigital, Samsung
2. W.r.t the Type-2 Codebook (Dynamic codebook):
	* Option 1: OPPO, Huawei, ZTE, CAICT, CATT, vivo, Intel, Lenovo, Spreadtrum, APT, InterDigital, Ericsson, Xiaomi, CMCC, Samsung, Apple, Qaulcomm

W.r.t the C-DAI and T-DAI counting, following details are listed:

* Alt-1: C-DAI and T-DAI count only PDSCH with feedback-enabled HARQ processes [LG]
	+ In the DCI of PDSCH with feedback-enabled HARQ processes, the C-DAI and T-DAI are given their true values (i.e., the count of feedback-enabled processes)
	+ In the DCI of PDSCH with feedback-disabled HARQ processes, the C-DAI and T-DAI are given their true values (i.e.,the count of feedback-enabled processes), despite they are not incremented.
* Alt-2: C-DAI and T-DAI count only PDSCH with feedback-enabled HARQ processes [Ericsson, Apple]
	+ In the DCI of PDSCH with feedback-enabled HARQ processes, the C-DAI and T-DAI are given their true values (i.e.,the count of feedback-enabled processes)
	+ In the DCI of PDSCH with feedback-disabled HARQ processes, the C-DAI and T-DAI are given a reserved value that can be ignored by the UE
* Alt-3: HARQ-ACK codebook only includes HARQ-ACK of enabled PDSCH [OPPO]
	+ C-DAI/T-DAI value in DCI scheduling enabled PDSCH is counted for enabled PDSCH
	+ C-DAI/T-DAI value in DCI scheduling disabled PDSCH is counted for disabled PDSCH
* Alt 4: HARQ-ACK codebook only includes HARQ-ACK of enabled PDSCH
	+ New parameter to count DAI for DCI carrying HARQ process with enabled feedback [ZTE]
* Alt 5: HARQ-ACK codebook only includes HARQ-ACK of enabled PDSCH
	+ C-DAI and T-DAI count both PDSCH with feedback-enabled HARQ processes and PDSCH with feedback-disabled HARQ processes [Xiaomi]
	+ Option 2: Panasonic, Nokia
1. W.r.t Type-3 Codebook:
	1. Supportive to enhancement: Huawei, ZTE, vivo, LG, Ericsson
		1. Solution 1: No feedback for HARQ process with disabled feedback [Huawei, ZTE, vivo, LG, Ericsson]
	2. Negative to enhancement: OPPO, CATT, Lenovo, Spreadtrum, Sony, Nokia

According to the above summary, the following proposals are listed as majority views:

**[Initial Proposal 2]:**

For the following HARQ codebook in NTN:

* Type-1 HARQ codebook: No enhancement is considered;
* Type-2 HARQ codebook: Reduce codebook size with HARQ-ACK codebook only includes HARQ-ACK of PDSCH with feedback-enabled HARQ processes
* Type-3 HARQ codebook:
	+ Alt-1: No enhancement
	+ Alt-2: Reduce codebook size with HARQ-ACK codebook only includes HARQ-ACK of PDSCH with feedback-enabled HARQ processes

Please provide your views below：

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| **Company** | **Comments and Views** |
| Panasonic  | Support proposal 2. Although exact meaning of “no enhancement” is not described, our understanding from companies’ contributions is that no enhancement means ACK/NACK information for HARQ-feedback disabled process is included in the HARQ-ACK codebook.  |
| OPPO | We are fine with the proposals for type 1 and type 2. For type 3, we question its benefit compared with type 1 and type 2. We have the followings concerns:1. In the current specification, type 3 cannot be configured alone but jointly configured with type 1 or type 2, which means that the UE cannot be configured to only report type 3.
2. Type 3 was introduced in NRU WI in order to benefit from the HARQ-ACK retransmission due to LBT failure. However, this benefit does not exist in NTN because the initial HARQ-ACK transmission can always be realized. Moreover, once the initial HARQ-ACK transmission is conducted, type 3 codebook only contains invalid NACK, which does not provide any information to the network.
3. Type 3 has larger codebook overhead, type 2 codebook is much more efficient than type 3.

With the above reasons, we don’t support type 3 codebook in NTN.  |

# **PDSCH/PUSCH scheduling restriction**

In RAN1#103e, following agreement has been achieved:

Agreement:

For a DL HARQ process with disabled HARQ feedback, the UE is not expected to receive another PDSCH or set of slot-aggregated PDSCH scheduled for the given HARQ process that starts until [X] after the end of the reception of the last PDSCH or slot-aggregated PDSCH for that HARQ process.

* FFS: value of X and units in which it is defined.
* FFS: Whether TB of the two PDSCHs needs to be different

Then, in this meeting, ***further views from 11 companies are summarized for PDSCH as:***

1. FFS: value of X and units in which it is defined.
	1. X is determined from N1 processing time [OPPO]
	2. X is T\_proc,1 for PDSCH [ZTE, vivo, APT, Apple]
	3. X is not include HARQ-ACK preparation time [CATT]
	4. X is one slot [Nokia]
	5. X=max (Tproc,1, Tslot\*k) where k is the minimum of minimum of  *dl-DataToUL-ACK* if configured and 0 otherwise. [Qualcomm]
2. FFS: Whether TB of the two PDSCHs needs to be different
	1. Different: OPPO, CATT
	2. No restriction: ZTE, vivo, Ericsson, Nokia

In addition, following two definition is proposed by [Ericsson] to clarify the definition of X:

* Definition 1: X is defined from the end of the reception of the last PDSCH or slot-aggregated PDSCH for a given HARQ process with disabled feedback to the start of the DCI scheduling another PDSCH or set of slot-aggregated PDSCH for the given HARQ process.
* Definition 2: X is defined from the end of the reception of the last PDSCH or slot-aggregated PDSCH for a given HARQ process with disabled feedback to the start of another PDSCH or set of slot-aggregated PDSCH for the given HARQ process.

The 1st definition is preferred by [Ericsson] to update the previous agreement and the value of X should be less than $T\_{proc,1}$ when the PDSCH is scheduled on a HARQ process with feedback disabled.

From moderator perspective, in existing specification, w.r.t the PDSCH scheduling, followings are defined in 38.214:

***PDSCH***

*For any HARQ process ID(s) in a given scheduled cell, the UE is not expected to receive a PDSCH that overlaps in time with another PDSCH. The UE is not expected to receive another PDSCH for a given HARQ process until after the end of the expected transmission of HARQ-ACK for that HARQ process, where the timing is given by Clause 9.2.3 of 38.213*

*If the first uplink symbol of the PUCCH which carries the HARQ-ACK information, as defined by the assigned HARQ-ACK timing K1 and the PUCCH resource to be used and including the effect of the timing advance, starts no earlier than at symbol L1, where L1 is defined as the next uplink symbol with its CP starting after* $T\_{proc,1}$ *,… , after the end of the last symbol of the PDSCH carrying the TB being acknowledged, then the UE shall provide a valid HARQ-ACK message.*

The first paragraph highlights the limitation on consecutive scheduling of PDSCH with same HARQ process, and the 2nd one refers to the minimum required time for PDSCH process including HARQ-ACK information preparation. More specifically:

* For the PDSCH scheduling:

In TN case, from the UE side, same HARQ process can be reused only after the transmission of HARQ-ACK with corresponding timing, which means that at gNB side, scheduling over one HARQ process is only available once the HARQ-ACK information of previous scheduling for given HARQ process is received.

But in NTN case, the intention of disabling of HARQ feedback is to resolve the impact of larger RTT and allow the scheduling with same HARQ process from gNB side without reception of HARQ-ACK feedback. So, the only issue is to avoid the overlapped PDSCHs reception with same HARQ process considering the UE’s capability of PDSCH processing.

* For the process timing:

In TN case, from the UE side, the minimum required time for PDSCH processing and HARQ-ACK preparation is defined as $T\_{proc,1}$. It should be noticed that the previous value is not coupled with the K1 (*HARQ-ACK timing K1* , i.e., *dl-DataToUL-ACK)* and the latter one is defined for timing of HARQ-ACK feedback to handling the potential impact of TA and PUCCH preparation.

However, in NTN case with disabled feedback, the scheduling restriction for PDSCH should only target for the PDSCH process without any consideration for HARQ-ACK feedback. Then, the X = $T\_{proc,1}$ is enough as the gap between two PDSCH with same HARQ process. W.r.t the further reduction of this value, e.g., to exclude the HARQ-ACK generation time, from moderator perspective, it’s not necessary to further define the UE capability and reuse the current spec is preferred to minimize the impacts on UE implementation.

Then, w.r.t the 2nd FFS on Whether TB of the two PDSCHs needs to be different, from moderator perspective, there is no need to introduce additional restriction on scheduling since supportive on the same TB is beneficial in same case as blind retransmission.

Based on the above analysis, following proposal is provided according to majority view:

**[Initial Proposal 3]:**

For a DL HARQ process with disabled HARQ feedback, the UE is not expected to receive another PDSCH or set of slot-aggregated PDSCH scheduled for the given HARQ process that starts until $T\_{proc,1}$ after the end of the reception of the last PDSCH or slot-aggregated PDSCH for that HARQ process.

* Note: The TB of the two PDSCHs can be either same or different

Please provide your views below：

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| **Company** | **Comments and Views** |
| Panasonic | Support proposal 3.  |
| OPPO | From our understanding, for PDSCH decoding without HARQ-ACK feedback, the time gap N1 is sufficient, because N1 already refers to the PDSCH processing time. There is no additional UE processing burden. But when it comes to FL’s proposal to further relax this time to Tproc,1, as a UE vendor, we are fine with this proposal.  |
|  |  |

Moreover, according to the recommendation in the FL summary is last meeting, ***further views from 5 companies w.r.t the PUSCH scheduling is summarized***:

[Qualcomm, OPPO, vivo] propose to define a minimum gap between two PUSCHs of a HARQ process, for example, T\_proc,2 is defined in [OPPO]. However, as proposed by [Ericsson, China Telecom], the existing scheduling rule should be kept for PUSCH.

From moderator perspective:

1. According to existing process, only HARQ feedback disabling for the DL transmission is agreed, no additional enhancement has been considered for UL transmission.

*Agreement:*

*Enabling/disabling on HARQ feedback for downlink transmission should be at least configurable per HARQ process via UE specific RRC signaling*

Agreement from RAN2#112e:

1. From RAN2 perspective, for dynamic grant, one possibility for "enabling"/"disabling" HARQ uplink retransmission at UE transmitter is without introducing an additional mechanism (i.e. gNB can send grant with NDI not toggled/toggled without waiting for decoding result of previous PUSCH transmission). FFS on the handling of RTT timers. Other solutions for enabling/disabling HARQ UL reTX are not precluded
2. In the existing specification, w.r.t the PUSCH scheduling, followings are defined in 38.214:

*The UE is not expected to be scheduled to transmit another PUSCH by DCI format 0\_0, 0\_1 or 0\_2 scrambled by C-RNTI or MCS-C-RNTI for a given HARQ process until after the end of the expected transmission of the last PUSCH for that HARQ process.*

*If the first uplink symbol in the PUSCH allocation for a transport block, including the DM-RS, as defined by the slot offset K2 and the start and length indicator SLIV of the scheduling DCI and including the effect of the timing advance, is no earlier than at symbol L2, where* *L2 is defined as the next uplink symbol with its CP starting* $T\_{proc,2}$ *after the end of the reception of the last symbol of the PDCCH carrying the DCI scheduling the PUSCH, then the UE shall transmit the transport block.*

Based on the above analysis, it’s clear that for enabling the consecutive transmission with same HARQ process, e.g., retransmission, no additional enhancement for the PUSCH scheduling is needed comparing to terrestrial network. Companies are encourage to justify the necessity.

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| **Company** | **Comments and Views** |
| OPPO | From the spec text, it seems to say that second DCI scheduling a second PUSCH corresponding to the same HARQ process, should be received by the UE after the first PUSCH. We think this restriction is not suitable for disabled PUSCH transmission. The reason is that the gNB does not have knowledge of exact UE-specific TA or UE specific RTT every time it schedules a PUSCH. Thus, the gNB might not be able to ensure this timing relationship. Therefore, with this restriction, it imposes the gNB to wait for a longer time to avoid this scheduling error case, contradicting the expected benefits from HARQ disabling.  |
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# **Restriction on HARQ feedback disabling**

In RAN1#102e meeting, following agreement has been achieved:

Agreement:

Enabling/disabling on HARQ feedback for downlink transmission should be at least configurable per HARQ process via UE specific RRC signaling

However, in current specification, some mechanisms, e.g., delivering MAC CE command, SPS release, depend on the ACK-NACK feedback. In this meeting, ***following views are summarized:***

1. MAC CE:

As highlighted by [APT, MTK, Sony, Ericsson, ZTE], further discussion is required for this issue. Both [MTK, Sony] prefer to send the LS to RAN2, and the following options can be included.

* Option 1: UE expects that at least one HARQ process for DL scheduling is configured for the scheduling of MAC-CE.
* Option 2: Up to gNB’s implementation for scheduling

[Ericsson] highlights that UE does not expect a MAC CE activation/deactivation command, which would become effective 3 msec after the UE would transmit the corresponding HARQ-ACK, to be scheduled on a downlink HARQ process with disabled feedback. And [ZTE] mentioned that such restriction can be gNB’s implementation.

1. SPS release:

As highlighted by [CAICT, CATT, ZTE, Sony, Apple], further discussion is required for this issue. More specifically, [CATT] highlights scheduling with feedback enabled HARQ process should be considered for SPS release and [Sony] prefer to allow the UE to conduct the ACK-NACK feedback even scheduled with feedback disabled HARQ process. [ZTE, CAICT] mention that the corresponding scheduling is up to gNB configuration and [ZTE] prefer to deliver information via enabled HARQ process.

According to the above summary, it’s clear that resolving the potential mismatch between UE’s and gNB’s behavior due to the introduction of feedback disabling is needed along with the discussion in previous meeting. Then, from moderator perspective, a unified solution for these cases is preferred as following proposal:

**[Initial Proposal 4]:**

For the transmission of MAC CE and SPS release, one of following is supported:

* Option-1: UE expects that at least one HARQ process is configured with HARQ feedback.
* Option-2: UE expects that MAC CE and SPS release information is scheduled via one HARQ process configured with HARQ feedback.
* Note: The Option 2 can be taken as Conclusion.

Please provide your views below：

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| **Company** | **Comments and Views** |
| Panasonic | Above options assumes gNB uses HARQ enabled process for the MAC CE and SPS release information. But, we think whether to use HARQ enabled or disabled process for the transmission of MAC CE and SPS release should be up to gNB implementation, as we mentioned in our contribution R1-2101024 for 8.4.1. When MAC CE is transmitted with HARQ disabled process, “slot used for the HARQ-ACK transmission” can be defined by K1 value in the DCI scheduling the HARQ disabled process as in HARQ enabled process. Therefore, we propose the following option. Option-3: whether to use HARQ enabled or disabled process for the transmission of MAC CE and SPS release is up to gNB implementation. |
| OPPO | Option 1 can be decided later once the HARQ-ACK codebook design is clear. For the moment, it is not needed to add this configuration restriction. For option 2, it is not clear why SPS release is associated with HARQ process? In NR spec, no HARQ process is needed for receiving SPS release.  |

# **Performance enhancements**

For enhancing the performance of transmission, in last meeting, different solutions including potential parameters configurations are proposed by companies. In this meeting, following aspects are categorized into following aspects according to the views from each company:

1. Enhancements on aggregated transmission (including repetition)
	* Larger aggregation factor:

As highlighted by [CATT, ETRI, ZTE], supports of the larger aggregation factor is beneficial for NTN.

* + Indication of aggregation factor:

[Ericsson, Lenovo, ETRI] prefer to introduce different configurations for the transmission via HARQ process with enabled or disabled feedback.

Meanwhile, DCI based indication for the repetition/aggregation related information is mentioned by [Huawei, Ligado, Lenovo, Samsung].

* + Transmission scheme:

In case of supports on larger aggregation factor, the time-interleaved transmission is mentioned in [CATT, CMCC]. Moreover, as results shown in [ZTE], performance gain can be achieved for the transmission with reduced DM-RS density. [Panasonic] proposes to introduce the scaling factor for TBS determination. And joint transmission with channel estimation cross slot is proposed by [OPPO].

1. Enhancements on CQI table with new BLER

A new CQI table with larger BLER e.g., 1% [InterDigital] is proposed by [InterDigital, Qualcomm]. But this part is not preferred by [ZTE] since similar performance can be achieved by implementation of scheduling, and also not needed as highlighted by [Thales] for NTN GEO scenario.

1. Blind retransmission

As highlighted by [OPPO, Thales, Apple], supports on blind PDSCH (re)transmission of the same packet by MAC scheduling without waiting for the transmission of the HARQ feedback can be considered.

1. UCI

As highlighted in [Xiaomi, Qualcomm, ETRI], in case of scheduling with disabled HARQ feedback, additional new UCI feedback, e.g., to report the decoding statistic or reporting DL transmission disruption and/or requesting DL scheduling changes, can be considered to improve the scheduling configuration from gNB side.

1. UE assistance information

As mentioned in [Samsung, Huawei], report for the assist information from UE side, e.g., the buffer situation in the DL HARQ procedure [Samsung] via reserved resource [Huawei], is beneficial for scheduling the decision for HARQ scheduling with enabled/disabled feedback.

In addition, other solutions, e.g., priority order for transmission [CAICT]., RV limitation for scheduling [QC] and TB size scaling [Panasonic], is proposed by proponent. No enhancement on MCS is highlighted by [CATT].

Based on the above analysis, following proposal is provided according to majority view:

**[Initial Proposal 5]:**

Study on following enhancements is prioritized:

* Enhancements on aggregated transmission (including repetition)
* Enhancements on MCS (including CQI report)

Please provide your views below：

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| **Company** | **Comments and Views** |
| Panasonic  | We are fine to discuss above two aspects. * Aggregated transmission (including repetition)

The number of repetitions up to 16 is supported in Rel.16. Although the necessity of the larger value is not yet clear, enhancement supported in coverage enhancement WI can be applied if needed. Repetition can be used to improve user throughput together with TB size scaling especially for Ka-band where slot length is small. For example, RTT up to 335 slots is observed in case of LEO 1200km with SCS 120kHz. Apparently, up to 32 processes restrict too much the transmission opportunities within RTT and degrade user throughput. By PDSCH/PUSCH transmission with TB size scaled with the number of repetitions (e.g. 4x TB size for 4x repetitions), user throughput is significantly improved as shown in our simulation results in R1-2101025. Note that similar benefit can be obtained by multi-slot transmission discussed in coverage enhancement WI. it can be considered to apply the same solution as multi-slot PUSCH in coverage enhancement WI for both PUSCH and PDSCH in NTN.* MCS (CQI) enhancement

The purpose of the enhancement seems to realize lower BLER transmission (e.g. 1 or 0.1%). We think lower BLER can be achieved by gNB’s MCS selection using the existing CQI/MCS tables.  |
| OPPO | We think blind retransmission is an important solution to enhance the performance, which is not sub-ordinary to aggregated transmission. We propose that blind retransmission should have the same priority as aggregated transmission for the discussion. Proposed modification on initial proposalStudy on following enhancements is prioritized:* Enhancements on aggregated transmission (including repetition)
* Enhancements on blind retransmission.
* Enhancements on MCS (including CQI report)
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# **Conclusion**

In this summary, following proposals are made according to the contribution submitted in AI 8.4.3:

# **Appendix**

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| Contribution | Observation/Proposals |
| R1-2100158 OPPO | Proposal 1: In addition to RRC configuring enabling/disabling of HARQ processes, RAN1 can investigate dynamic switching between enabling/disabling HARQ processes via DCI.Proposal 2: For Type-1 HARQ codebook, Option-1 is supported, i.e., HARQ-ACK information for disabled DL HARQ processes should be reported in Type-1 HARQ-ACK codebook.Proposal 3: For Type-2 HARQ codebook, Option-2 is supported, i.e., HARQ-ACK information for disabled DL HARQ processes should be reported also in Type-2 HARQ-ACK codebook.Proposal 4: For enhanced Type-2 HARQ-ACK codebook, HARQ-ACK codebook, it should be designed with the following principles* only includes HARQ-ACK of enabled PDSCH;
* C-DAI/T-DAI value in DCI scheduling enabled PDSCH is counted for enabled PDSCH;
* C-DAI/T-DAI value in DCI scheduling disabled PDSCH is counted for disabled PDSCH;

Proposal 5: Type-3 HARQ codebook is not supported in NR-NTN. Proposal 6: The value of X is determined from N1 processing time and TBs of the two PDSCHs needs to be different. Proposal 7: PUSCH transmission constraint for a given disabled UL HARQ process should be considered. Proposal 8: Enhancements to PDSCH/PUSCH with disabled HARQ process to achieve a higher reliability should be considered. Proposal 9: Option 1 or Option 1a should be supported for enhanced HARQ process ID indication. Proposal 10: PDSCH reception constraint for a given enabled DL HARQ process should be clarified in NTN. Proposal 11: PUSCH transmission constraint for a given enabled UL HARQ process should be clarified in NTN.  |
| R1-2100224Huawei, HiSilicon | Observation 1: Slot index as MSB of HARQ process ID is more flexible for UE with supportable HARQ process number not lager than 16.Observation 2: Explicit Indication of HARQ process ID via reusing idle bits depends on DCI format design.Proposal 1: Extending HARQ process ID field shall be precluded.Proposal 2: Implicit indication of HARQ process ID via binding MSB of HARQ process ID with slot index is first preferred.Proposal 3: The HARQ-ACK feedback for a disabled HARQ process in case of Type1 and Type3 HARQ-ACK codebook is not useful.Proposal 4: Optimization on HARQ process scheduling by skipping HARQ disabled transmission occasions can be considered for reducing Type-1 and Type-3 codebook size.Proposal 5: For Type-2 codebook, DAI is not count for scheduled PDSCH from disabled HARQ process.Proposal 6: Aggregation transmission parameters can be configurable and indicated via DCI.Proposal 7: Reinterpreting idle bits in DCI for indicating transmission parameters shall be considered.Proposal 8: UE assistance information reporting in reserved resource can be considered for NTN. |
| R1-2100246 ZTE | Proposal 1: Re-interpretation of bits in DCI should be considered as the baseline to support the HARQ process indication with extended maximum HARQ process number.Proposal 2: For Type-2 codebook, enhancement to enable the DAI counting only for HARQ process with enabled feedback is supported via introducing of additional parameters. Proposal 3: For Type-3 codebook, enhancement can be enabled by only allowing the ACK-NACK generation for HARQ process with enabled feedback.Proposal 4: The link budget listed in 38.821 can be used to evaluate the UL performance for mobile UE with consideration on the potential enhancements introduced in coverage enhancement WI.Proposal 5: Enlarged aggregation factor and reduced DM-RS density should be supported to improve the performance for NTN.Proposal 6: Following enhancements are not needed to be supported.* + Blind transmission:
	+ CQI with new BLER target
	+ UCI including DL decoding Infor/MCS request
	+ Different parameters configuration
		1. MCS table
		2. Time domain resource allocation table
		3. Frequency resource allocation type 0 and type 1
		4. Block error rate target
		5. Physical resource block (PRB) bundling configuration
		6. PDSCH mapping type A and type B

Proposal 7: X = Tpro,1 is considered as minimum gap for the between PDSCHs scheduled with same HARQ ID in case of disabled HARQ feedback. |
| R1-2100306CAICT | Proposal 1: Support option 3 for all DCI formats.Proposal 2: Configure two subsets of HARQ processes for enabled HARQ processes and disabled HARQ processes respectively via RRC signaling. To decide the HARQ disable/enable state with HARQ process ID indication in the scheduling DCI.Proposal 3: HARQ-ACK for disabled HARQ is not included in the dynamic HARQ-ACK codebook.Proposal 4: Consider enhancements on DCI formats and corresponding PDCCH detection when DL HARQ process with feedback disabled and enabled are simultaneously supported for one UE.Proposal 5: Enabling/disabling of HARQ feedback for DL SPS/UL CG is configured per configuration.Proposal 6: Provide higher priority order for the HARQ disabled transmission than the priority order for HARQ enabled transmission. |
| R1-2100383CATT | Observation 1: HARQ ID indication using slot index as the LSB seems reasonable.Observation 2: Additional HARQ bit can be taken from second block DCI field if only one layer tansmission supported in NTN. 1. Consider to use slot index or DCI field of second block as additional HARQ bit indication to support 32 HARQ processes in DCI 0-2/1-2 and DCI 0-1/1-1.
2. Maximum 16 HARQ processes for DCI 0-0 and maximum 8 HARQ processes for DCI 1-0 can be supported.
3. No enhancement is needed for type 1 HARQ-ACK codebook.
4. Type 2 HARQ-ACK codebook can be optimized, and the counter DAI and total DAI for a PDSCH with a feedback disabled HARQ process are the same as the previous PDSCH with a feedback enabled HARQ process.
5. For SPS case, the HARQ-ACK feedback for activation and release command can be enabled.
6. Type 3 HARQ-ACK codebook is not needed in NTN case.
7. UE expects that at least one HARQ process with feedback is configured for the scheduling of MAC-CE.
8. Slot aggregation factor can be extended to 16 for very low SINR case.
9. Support time interleaved slot aggregation to improve transmission reliability.
10. There is no need for the enhancement on MCS.
11. The minimum time gap between two neighboring disabled PDSCHs with same HARQ ID should not include HARQ-ACK preparation time.
12. From UE perspective, the TBs of two neighboring PDSCHs with same HARQ ID in HARQ disabling case should be different.
 |
| R1-2100443vivo | Observation 1: The gNB can transmit the DCI of scheduling a PUSCH for a given HARQ process before it receives the previous PUSCH transmission for the same HARQ process.* The time gap of the two DCI scheduling the same HARQ process should be not smaller than the slot offset K2 .
* The absolute time of the DCI arriving at UE should after the end of the expected transmission of the last PUSCH for the same HARQ process.
* The downlink frame/slot number of the DCI arriving at UE may be less than uplink frame/slot number of the transmission of the previous PUSCH for the same HARQ process.

Proposal 1：Enhanced HARQ process ID indication is supported by the following:* For DCI 0-1/1-1 and DCI 0-2/1-2, extending the HARQ process ID field to 5 bits.
* For DCI 0-0/1-0, re-interpreting existing DCI field to indicate the extension of HARQ ID.

Proposal 2：HARQ codebook enhancements are supported as:* For Type-1 HARQ codebook:
	+ If both enabled HARQ processes or SPS release and disabled HARQ processes are transmitted in the  occasions, no enhancement.
	+ If only disabled HARQ processes are transmitted in the occasions, omit the HARQ-ACK report.
* For Type-2 HARQ codebook:
	+ HARQ-ACK codebook only includes HARQ-ACK of PDSCH with enabled HARQ processes and SPS release.
	+ The value of T-DAI in a DCI format denotes the total number of {serving cell, PDCCH monitoring occasion}-pair(s) in which PDSCH reception(s) with enabled HARQ and SPS PDSCH release associated with the DCI formats up to the current PDCCH monitoring occasion.
	+ The value of C-DAI in a DCI format denotes the accumulative number of {serving cell, PDCCH monitoring occasion}-pair(s) in which PDSCH reception(s) with enabled HARQ or SPS PDSCH release associated with the DCI formats up to the current serving cell and current PDCCH monitoring occasion.
* For Type-3 HARQ codebook:
	+ HARQ-ACK codebook includes HARQ-ACK of all the enabled HARQ processes in one shot.

Proposal 3：For a DL HARQ process with disabled HARQ feedback, the UE is not expected to receive another PDSCH or set of slot-aggregated PDSCH scheduled for the given HARQ process until after the end of the reception of the last PDSCH or slot-aggregated PDSCH for that HARQ process.* The TB of the two PDSCHs can be same or different.
 |
| R1-2100485 Ligado | The following are the main conclusions.* For heavy blockage, as represented by the Heavy Tree-Shadowed environment, ABR yields a substantial improvement over the legacy, No-Repeat system.
* The improvement is greater for higher coding rate (higher open-sky throughput) systems than lower coding rate systems.
* For moderate to light blockage, ABR and No-Repeat systems have approximately similar throughputs, although ABR does perform 10 – 20% better.
* The lower BLERs of ABR relative to No Repeat show the effectiveness of packet repetition.
 |
| R1-2100491BUPT | Observation 1: Under different channel scenarios, the system with HRAQ process ID indication enhancement has obviously higher throughput than that has 4 bits of HARQ process ID field.Observation 2: ACBG-HARQ can significantly reduce the memory overflow probability of the receiver and improve the transmission spectrum efficiency of the system.Observation 3: In different channel scenarios, the transmission performance degradation caused by memory overflow is different, and the gain brought by the HARQ mechanism with adaptive code block group size is different.Proposal 1: Within the capacity of the communication system, more HARQ processes should be supported to achieve higher system throughput gain.Proposal 2: In NTN scenarios, the HARQ mechanism should add the indicator symbol of memory state in UCI, and adjust the CBG size of transmission according to memory state information, so as to reduce the memory consumption and improve the spectrum efficiency of the system.Proposal 3: In different channel scenarios, the decline of system transmission performance is different due to receiver memory overflow. The smaller the CBG transmission size will lead to the increase of the number of HARQ feedback information, so the selection of CBG size should be optimized according to the system requirements. |
| R1-2100596 MTK | Proposal 1: Support of 32 HARQ processes in the device is a UE capability in NR NTN.Proposal 2: Support one of the following options for enhanced HARQ process ID indication:* Option 2: Reuse one bit from DCI RV field, where only RV0 is used, or RV0 and RV3 are used.
* Option 3: Extending the HARQ process ID field up to 5 bits

Observation 1: Reporting a NACK on HARQ process with disabled UL HARQ feedback should not be seen as an enhancement, as it the simplest way to apply the existing specifications.Proposal 3: For Type-1 HARQ codebook, support Option-2: Report NACK on disabled processProposal 4: For Type-2 HARQ codebook, support Option-2: No enhancements.Observation 2: It is up to gNB implementation if UL HARQ feedback is not disabled for Message 3 during initial access.Proposal 5: A LS to RAN2 with capturing following options is needed to resolve the issue related to MAC CE activation/deactivation command:* Option 1: UE expects that at least one HARQ process for DL scheduling is configured for the scheduling of MAC-CE.
* Option 2: Up to gNB’s implementation for scheduling

Observation 3: In NR specifications, the MCS selection, time domain allocation, and frequency resource allocation type 0 and type 1 can be done first as in the specifications. Then, repetitions with values 2, 4, or 8 to increase the reliability of each transmissions as in URLLC can be done based on pdsch-AggregationFactor for DL or repK for UL based on RRC configuration. Increasing value for pdsch-AggregationFactor for DL or repK for UL to 16 or 32 has minimum impact on the specification.Proposal 6: Support higher level of slot aggregation / repetitions 16 or 32* FFS DMRS time bundling with level of slot aggregation / repetitions > 8

Proposal 7: For a DL HARQ process with disabled HARQ feedback, the UE is not expected to receive another PDSCH or set of slot-aggregated PDSCH scheduled for the given HARQ process that starts until N1 symbols after the end of the reception of the last PDSCH or slot-aggregated PDSCH for that HARQ process, where N1 is as defined in TS 38.214, Tables 5.3-1 and 5.3-2. |
| R1-2100656 Intel | Proposal 1: * Support Rel. 15 Type I HARQ codebook for the case where HARQ feedback is disabled for a subset of HARQ processes
* For Type II HARQ codebook, PDSCH with disabled HARQ feedback is not counted for DAI and the corresponding ACK/NACK is not transmitted by the UE

Proposal 2: * HARQ process ID is determined based on DCI indication and slot index of the corresponding transmission as MSB or LSB
	+ 4 bits are used for HARQ process ID indication in DCI
 |
| R1-2100705LG | Proposal 1: For enhanced HARQ process id identification in NTN, support option 3 (Extending the HARQ process ID field up to 5 bits) with non-fallback DCI (DCI 0-2/1-2 and DCI 0-1/1-1) only.Proposal 2: FFS on the use case and clear benefit of dynamic HARQ enabling/disabling. Proposal 3. For transmission enhancement when HARQ feedback is disabled, consider recommended repetition factor, PDSCH decoding results or probability as new CSI contents. Proposal 4. Discuss PDSCH scheduling restriction if two PDSCHs are associated with different HARQ process id and one of two PDSCHs is HARQ feedback disabled. Proposal 5. For Type-1 HARQ-ACK codebook enhancement, option 3 (reduced codebook size with criteria) is preferred. Proposal 6. For Type-2 HARQ-ACK codebook enhancement, HARQ-ACK codebook only includes HARQ-ACK of PDSCH with feedback-enabled HARQ processes, and the C-DAI and T-DAI are given their true values (i.e., the count of feedback-enabled processes) in the DCI of PDSCH with enabled/disabled HARQ processes.Proposal 7. UE feedbacks acknowledgement for the reception of SPS activation DCI, if the first PDSCH after reception of the SPS activation DCI is with disabled HARQ process. Proposal 8. Support enhancements on Type-3 HARQ-ACK codebook by including enabled HARQ processes only.  |
| R1-2100759Lenovo | Proposal 1: The HARQ process number is tied to SFN/slot index of PDCCH/PUSCH/PDSCH for DCI format 0-0/1-0 and DCI format 0-1/1-1 if UE is configured with HARQ process number of 32.Proposal 2: For DCI 0-2/1-2, the HARQ process number field in DCI is determined to higher layer parameter.Proposal 3: Different numbers of HARQ processes is configured based on UE capability.Proposal 4: UE assumes the HARQ feedback disabling where HARQ ID belongs to the RRC configured HARQ process disabling subset.Proposal 5: The multiple transmissions of same TBs in consecutive or interlaced slots can be considered when HARQ is disabledProposal 6: Repetition transmission number and interlace transmission interval can be indicated in corresponding DCI when HARQ process disabling.Proposal 7: A unified configuration should be considered for each HARQ process with/without feedback except aggregation factor if benefit identified.Proposal 8: For Type 1 HARQ-ACK codebook, no enhancement is needed for NR NTN.Proposal 9: For Type 2 HARQ-ACK codebook, HARQ-ACK codebook only includes HARQ-ACK of PDSCH with HARQ feedback enabled, and counter DAI and total DAI are not increased for a PDCCH with HARQ feedback disabled.Proposal 10: Type 3 HARQ-ACK codebook is not supported for NR NTN. |
| R1-2100809Spreadtrum | Proposal 1: Option 2 and Option 3 should be considered for HARQ process ID indication.Proposal 2: Blind retransmission and larger aggregation/repetition factor can be considered for enhancing the performance of transmission.Proposal 3: Option-1 for Type-2 HARQ codebook enhancement and Option-2 for Type-1 HARQ codebook enhancement should be considered. |
| R1-2100861Sony | Observation 1: When HARQ feedback is disabled for some HARQ processes, the redundant feedback bits of Type-1 / semi-static HARQ-ACK codebook would be large based on current HARQ-ACK codebook designProposal 1: Unified solution of HARQ process indication for all DCI formats, down select from following options:* Option 1: Slot index as the MSB
* Option 1-a: Slot index as the LSB
* Option 2: Reusing one bit from other bit field
* Option 3: Extending the HARQ process ID field up to 5 bits

Proposal 2: Send LS to RAN2 with capturing following options to resolve the issue related to MAC CE activation/deactivation command:* + Option 1: UE expects that at least one HARQ process with feedback enabled is configured for the DL scheduling of MAC CE.
		- FFS all MAC CE need mandatory HARQ process with feedback enabled.
	+ Option 2: Up to gNB’s implementation for scheduling.
		- FFS the timing relationship of MAC CE activation/deactivation via HARQ process with HARQ feedback disabled.

Proposal 3: HARQ codebook enhancement is supported as:* For Type-1 HARQ codebook, reduce codebook size with keeping the codebook size semi-static.
* For Type-2 HARQ codebook, reduce codebook size with HARQ codebook only includes HARQ-ACK of dynamic scheduling PDSCH with feedback-enabled HARQ process.
	+ C-DAI, T-DAI and DAI in DCI format 0\_1 count only DCI scheduling PDSCH with HARQ-ACK enabling.
		- In both DCI of PDSCH with feedback-enabled HARQ processes and feedback-disabled HARQ processes, the C-DAI and T-DAI are given the count value of feedback-enabled process.
* Don’t support Type-3 HARQ codebook in NTN.

Proposal 4: When the HARQ process of SPS PDSCH is HARQ feedback disabled, UE reports HARQ feedback information for the SPS PDSCH activation. Proposal 5: The counter DAI, total DAI and DAI in DCI format 0\_1 count for PDCCH indicating SPS PDSCH activation for HARQ process with feedback disabled. |
| R1-2100913China Telecom | Proposal 1: Enhanced HRAQ process ID indication is supported by either,Opt 1: Reusing one bit from other bit field as a unified solution for all DCI formats, orOpt 2: Extending the HARQ process ID field up to 5 bits for other DCI formats while DCI 0\_0/1\_0 remains the same.Proposal 2: Type-1 HARQ codebook can be enhanced by reducing the codebook size.Proposal 3: The existing scheduling rule should be kept for PUSCH. |
| R1-2100928Ericsson | Observation 1 It is not necessary to schedule 32 HARQ processes using fallback DCI 0\_0/1\_0.Observation 2 Adding an additional configurable bit in DCI 0\_1/1\_1 and/or 0\_2/1\_2 to support 32 HARQ processes minimizes the impacts on specification and scheduling.Observation 3 Time window-based method (and its variations) for supporting 32 HARQ processes is not aligned with asynchronous NR HARQ design principle, introduces unnecessary scheduling restriction, and thus is against the RAN1 agreement of “minimizing the impacts on specification and scheduling.”Observation 4 Reusing one bit from other bit field to indicate 32 HARQ processes is not a clean design approach. Such hack in the specification should in general be avoided, as it can easily cause confusion and complications in the specification.Observation 5 If the reused bit is from a field that is not applicable when HARQ feedback is disabled, it will couple two features, i.e., 32 HARQ processes can only be used when HARQ feedback is disabled, which is highly undesirable.Observation 6 The intention of disabling HARQ feedback for a downlink transmission is not to send HARQ feedback for the downlink transmission.Observation 7 If the network schedules a PDSCH on a HARQ process with feedback disabled, it is clear that the network is not interested in receiving the feedback.Observation 8 Sending feedback from UE for a HARQ process with disabled feedback leads to waste of radio resource and UE power consumption, as well as increased interference.Observation 9 RAN1 already agreed that Type-3 HARQ codebook can be applied beyond unlicensed spectrum.Observation 10 NR is a toolbox of features. Each feature should not be limited to a certain use case or deployment and it is up to implementation to use it as fit.Observation 11 There should not be some artificial restriction that Type-3 HARQ codebook is not applicable to NTN.Observation 12 The uplink HARQ process reuse rule that “the UE is not expected to be scheduled to transmit another PUSCH for a given HARQ process until after the end of the expected transmission of the last PUSCH for that HARQ process” does not impose restriction that would lead to throughput reduction in the presence of large RTT, regardless of whether the DL and UL frame timings are aligned or not at the gNB/UE.Observation 13 The downlink HARQ process reuse rule that “the UE is not expected to receive another PDSCH for a given HARQ process until after the end of the expected transmission of HARQ-ACK for that HARQ process” is not applicable to a HARQ process with feedback disabled.Proposal 1 Whether 32 HARQ processes are used or not in the uplink can be configured by RRC.Proposal 2 Whether 32 HARQ processes are used or not in the downlink can be configured by RRC.Proposal 3 If 32 HARQ processes are configured, an additional bit is present in DCI 0\_1/1\_1. This additional bit, together with the existing 4 bits in the HARQ process ID field, can be used to indicate 32 HARQ processes.Proposal 4 If 32 HARQ processes are configured, the size of the HARQ process ID field in DCI 0\_2/2\_2 is 5 bits.Proposal 5 UE does not expect a MAC CE activation/deactivation command, which would become effective 3 msec after the UE would transmit the corresponding HARQ-ACK, to be scheduled on a downlink HARQ process with disabled feedback.Proposal 6 RAN1 to discuss what parameters need to be configured differently for HARQ processes with feedback and HARQ processes without feedback. One example parameter is aggregation factor.Proposal 7 When HARQ processes are enabled/disabled on a per HARQ process basis, in the case of the NR Type-1 HARQ codebook, the UE inserts NACKs in positions corresponding to PDSCHs associated with feedback disabled HARQ processes.Proposal 8 When HARQ processes are enabled/disabled on a per HARQ process basis, in the case of the NR Type-2 HARQ codebook, the codebook only includes HARQ-ACK of enabled PDSCH, and: C-DAI/T-DAI value in DCI is counted only for feedback enabled HARQ processes C-DAI/T-DAI field in DCI scheduling feedback disabled HARQ process is reserved.Proposal 9 When HARQ processes are enabled/disabled on a per HARQ process basis, in the case of the NR Type-3 HARQ codebook, the codebook size is dimensioned to include ACK/NACK information only for HARQ processes that are enabled.Proposal 10 Keep the existing uplink HARQ process reuse rule.Proposal 11 X is defined FROM the end of the reception of the last PDSCH or slot-aggregated PDSCH for a given HARQ process with disabled feedback TO the start of the DCI scheduling another PDSCH or set of slot-aggregated PDSCH for the given HARQ process.Proposal 12 The value of X should be less than $Tproc,1$ when the PDSCH is scheduled on a HARQ process with feedback disabled.Proposal 13 The scheduling restriction applies regardless of whether the TB of the two PDSCHs is the same or different, i.e., it is up to gNB scheduling. |
| R1-2100973APT,FGI | Observation 1 In principle, the Type-1 HARQ-ACK codebook has a fixed codebook size and the Type-2 HARQ-ACK codebook has a dynamic codebook size.Proposal 1 Reuse $Tproc,1$ in Rel-16 NR for the value of X and units for the PDSCH scheduling restriction when HARQ-ACK is disabled.Proposal 2 Support a single value of X for PDSCH scheduling restriction that can be applied for the same or different PDSCHs.Proposal 3 RAN1 shall confirm the support on the maximal HARQ process number is up to UE capability.Proposal 4 To support HARQ > 32, the use of fallback DCI formats, i.e., DCI 0-0/1-0, shall be justified with a reasonable need.Proposal 5 At least for DCI format 1\_2, Option 3: Extending the HARQ process ID field up to 5 bits shall be supported.Proposal 6 For Type-2 HARQ codebook, support Option-1: Reduce codebook size with HARQ-ACK codebook only includes HARQ-ACK of PDSCH with feedback-enabled HARQ processesProposal 7 For the Type-2 HARQ codebook to support Option-1, a possible enhancement shall reuse the existing pseudo-code given in TS 38.213 by adding a new procedure at the end of the pseudo-code to further reduce its codebook size.Proposal 8 RAN1 shall discuss a possible consequence if a UE receives a MAC CE activation/deactivation command without HARQ-ACK protection. |
| R1-2100986InterDigital | Observation-1: lowering target BLER for PDSCH when HARQ feedback is disabled is beneficial in terms of resource utilization and latency as it can reduce the number of retransmissions in higher layerObservation-2: use of a CQI table with a lower BLER target (e.g., 1%) could provide a better link adaptation with lower PDSCH BLER target when HARQ feedback is disabledProposal-1: a CQI table with a new target BLER (e.g., 1%) is considered when HARQ feedback is disabledProposal-2: blind retransmission is considered when HARQ feedback is disabledProposal-3: support extending the HARQ process ID field up to 5 bits (i.e., Option 3)Proposal-4: support Option-3 for Type-1 HARQ CB and Option-1 for Type-2 HARQ CB |
| R1-2101025Panasonic | Proposal 1: 1 bit is added for HARQ process ID indication in DCI format 0\_1, 1\_1 and 0\_2, 1\_2.Proposal 2: Enhancement of PDSCH/PUSCH transmission to improve user throughput without further increasing the number of HARQ processes should be discussed.Proposal 3: Transport block size scaling in case of repetition should be considered to improve user throughput with a limited number of HARQ processes. Alternatively, it should be considered to apply the same solution as multi-slot PUSCH in coverage enhancement WI for both PUSCH and PDSCH in NTN. Proposal 4: For both type 1 and type 2 HARQ-ACK codebook for HARQ-feedback disabled process, no change of UE behaviour from Rel.15/16, i.e. generate HARQ-ACK even for HARQ-feedback disabled process and include it in the HARQ-ACK codebook. |
| R1-2101044CMCC | Observation 1: For type-1 HARQ-ACK codebook, error cases may occur for Option 3 (Reduce codebook size with criteria) if the HARQ-ACK codebook is determined based on dynamic scheduling.* If any DCI of PDSCH with feedback-disabled HARQ process was miss-detected, miss understanding may occur on the bit size of the Type-1 HARQ-ACK codebook between the gNB and the UE.
* The position of ACK/NACK for PDSCH with feedback-enabled HARQ process in the reported Type-1 HARQ-ACK codebook are not fixed, and it depends on which one of the DCIs of PDSCH with feedback-disabled HARQ process was miss-detected.

Observation 2: For type-1 HARQ-ACK codebook, scheduling flexibility may be significantly reduced for Option 3 (Reduce codebook size with criteria) if the HARQ-ACK codebook is determined based on semi-static scheduling.Observation 3: For type-2 HARQ-ACK codebook, even if the UE identified DCI miss detection event for PDSCH with feedback-disabled HARQ processes, the UE can NOT trigger RLC retransmission due to unknow the SN of the corresponding RLC PDU.Proposal 1: At least support extending the HARQ process ID field up to 5 bits for DCI 0-2/1-2 and DCI 0-1/1-1.Proposal 2: At least support extending the HARQ process ID field up to 5 bits for DCI 0-0/1-0.Proposal 3: For type-1 HARQ-ACK codebook, down select Option 1 (No enhancement).Proposal 4: For type-2 HARQ-ACK codebook, Option-1 (Reduce codebook size with HARQ-ACK codebook only includes HARQ-ACK of PDSCH with feedback-enabled HARQ processes) can be supported.Proposal 5: For type-2 HARQ-ACK codebook enhancement with reduced codebook size, disable the C-DAI field and T-DAI field in DCI of PDSCH with feedback-disabled HARQ processes can be considered.Proposal 6: Enhancement on aggregated transmission (including repetition) can be prioritized. |
| R1-2101080ETRI | Observation 1 : The worst scenarios for transmission correspond to the cases having both GEO and handheld.* For SC5, the DL geometry SINR range might be from 1.5 dB (5%) to 5 dB (95%).
* For other cases (SC{4,19,20}), the DL geometry SINR range might be from -6 dB (5%) to 1 dB (95%).

Observation 2 : The slot aggregation (aggregation factor>1) could enhance BLER and SE simultaneously within low S(I)NR ranges.Observation 3 : The slot aggregation (aggregation factor> 1) might be inevitable for achieving target BLER.Observation 4 : The change of aggregation factor might be needed for achieving optimal SE performance.Observation 5 : If more challenging target BLER than 10-2 is required, 8 aggregated transmission (aggregation factor=8) might be insufficient for NTN.Observation 6 : For optimal adaptation, different aggregation factor might be applied depending on the parameter (especially IMCS).Observation 7 : For optimal adaptation, different aggregation factor should be applied depending on the target performance.Observation 8 : In NR, various kinds of transport channels are multiplexed into PDSCH/PUSCH.* Target performance of each transport channel might be distinguishable by checking the RNTI

Observation 9 : In NTN, different target performance might be defined by the HARQ feedback availability.Observation 10 : The value of aggregation factor should be determined properly if slot aggregation is used. * Too reliable parameter : throughput loss
* Proper parameter : optimal adaptation
* Too un-reliable parameter : reliability/latency loss (might be unable to communicate)

Observation 11 : NR gNB cannot distinguish between just proper parameter and too reliable parameter, if the slot aggregation is used. * 0 CRC OK in a bundle (too un-reliable parameter) : NACK
* only 1 CRC OK in a bundle (proper parameter) : ACK
* multiple(>1) CRC OK in a bundle (too reliable parameter) : ACK

Observation 12 : NR gNB cannot optimally react to some cases, if the slot aggregation is used.* toward better reliability : possible (reaction for receiving NACK quite consistently)
* maintain : possible (reaction for receiving ACKs quite consistently)
* toward better throughput : (seems to be )impossible

Observation 13 : In NR, there is no feedback mechanism to guide aggregation factor into lower value for better throughput* Once the aggregation factor value gets larger, it may be impossible to be reduced again

Observation 14 : If all the HARQ feedback are disabled, gNB cannot optimally react to all cases* toward better reliability : (seems to be )impossible
* maintain : (seems to be )impossible
* toward better throughput : (seems to be )impossible

Observation 15 : UL feedback might be helpful to guide aggregation factor into optimal value* non-optimal value might lead the throughput loss from 15% to 72%.

Observation 16 : UL feedback via MAC-CE/RRC might be preferred rather than UL feedback via UCI.* specification impact would be minimized
* soft combinable retransmission mechanism on PUSCH might be beneficial for compensating in low S(I)NR under NTN

Proposal 1 : Consider the enhancement via “larger aggregation factor” as the one of the NTN’s transmission enhancement solutions for achieving target BLER performance.Proposal 2 : Consider the enhancement via “different aggregation factors” as the one of the NTN’s transmission enhancement solutions.* the followings might be a start point for configuring different aggregation factors
	+ (a group of) MCS index
	+ (a group of) RNTI type (or search space)
	+ HARQ feedback availability (enabled/disabled)
	+ combinations of the above
	+ subsets of the above

Proposal 3 : Consider the enhancement via “UL feedback” as the one of the NTN’s transmission enhancement solutions for achieving better adaptation performance.* UL feedback can include information such as
	+ request for guiding pdsch-AggregationFactor
	+ decoding statistics
	+ combination of the above
* MAC-CE/RRC might be also acceptable, instead of UCI.
	+ for minimizing specification impact.
	+ for compensating low S(I)NR in NTN by using soft combinable retransmissions on PUSCH

Proposal 4 : For “Option 2: Reusing one bit from other bit field” to support enhanced HARQ process ID indication for DCI 0-2/1-2 and DCI 0-1/1-1, either MSB or LSB in the 2-bit redundancy version field can be considered. |
| R1-2101119Xiaomi | Proposal 1: The number of supported HARQ processes is subject to the UE’s capability.Proposal 2: Slot index as MSB or LSB can be taken as additional indication to support more than 16 HARQ processes.Proposal 3: The enhancement on the type 1 codebook design is not desired.Proposal 4: C-DAI and T-DAI count both PDSCH with feedback-enabled HARQ processes and PDSCH with feedback-disabled HARQ processes.Proposal 5: Dynamic HARQ enabling/disabling is not supported.Proposal 6: Enhancement on the UCI reporting such as the data decoding statistics should be introduced. |
| R1-2101208Samsung | Proposal 1: Enhanced Type-2 and Type-3 HARQ-ACK codebooks are not supported for NTN. Proposal 2: Enable a gNB to avoid HARQ-ACK information in a Type-1 HARQ-ACK codebook for HARQ processes with disabled HARQ-ACK information by configuring a bitmap that indicates slots where the UE should generate HARQ-ACK information. Proposal 3: When HARQ-ACK information for a HARQ process with disabled HARQ-ACK information is included in a HARQ-ACK codebook, the UE reports* A predetermined HARQ-ACK information value, such as a NACK, for the HARQ process with disabled HARQ-ACK information when the UCI payload size is no more than 11 bits.
* HARQ-ACK information based on a reception outcome of a corresponding TB for the HARQ process with disabled HARQ-ACK information when the UCI payload size is more than 11 bits.

Proposal 4: A Type-2 HARQ-ACK codebook only includes HARQ-ACK information for HARQ processes with enabled HARQ-ACK information report. * DAI values change only when a TB in a corresponding PDSCH is associated with HARQ process with enabled HARQ-ACK information report.

 Proposal 5: Support a larger number of repetitions for NTN * The number of repetitions is indicated by the DCI format as in Rel-16.
* Extend the “Time domain resource assignment” field or add a new field to indicate the increased number of repetitions.

Proposal 6: For the HARQ process ID indication, extend the HARQ process ID field up to 5 bits when the number of HARQ processes is 32.Proposal 7: For the maximum number of HARQ processes, support the following options. * Option 1. gNB broadcasts the maximum TBS to be configured for the cell and UE reports its capability for a number of HARQ processes.
* Option 2. UE reports its capability for a number of pairs of {maximum number of HARQ processes, maximum TBS constraint}.

Proposal 8: UE assistance information for HARQ should be supported for NTN. |
| R1-2101289Thales | Observation 1: 1% BLER target reduces RLC throughput by 7%.Observation 2: The transport block error rates in low-speed geostationary simulations are significantly below the BLER targetsObservation 3: There is no significant difference in transport block error rates for 1% and 10% BLER targetsObservation 4: CQI table inaccuracy further decreases the selected MCS and error rates in many casesObservation 5: Enabling blind PDSCH retransmissions for all UEs wastes resources and drops throughput significantlyObservation 6: A single blind PDSCH retransmission was able to reduce the error rate from 0.5% to 0%.Observation 7: NLOS UEs do not get any TP while LOS UEs always get some TP.Observation 8: The presence of NLOS UEs leaves more resources for LOS UEs therefore increasing their TP.Observation 9: The TP distribution of LOS UEs is not impacted by the presence of NLOS UEs.Observation 10: The dynamic channel condition simulations are more difficult to analyse.Proposal 1: No need for new BLER target in low-speed NTN GEO scenario.Proposal 2: Allow to send blind PDSCH (re)transmission of the same packet by MAC scheduling without waiting for the transmission of the HARQ feedback.Proposal 3: Blind retransmissions should be possible to configure per UE.Proposal 4: For GEO scenarios change the channel model to a LOS only channel model meaning instead of Table 6.6.1-1 of TR 38.811[5] use 100% LOS probability. |
| R1-2101298Nokia | Proposal 1: Define [X] to have a value of 1 slot.Proposal 2: For a DL HARQ process with disabled HARQ feedback, the UE is not expected to receive another PDSCH or set of slot-aggregated PDSCH scheduled for the given HARQ process that starts until 1 slot after the end of the reception of the last PDSCH or slot-aggregated PDSCH for that HARQ process.Proposal 3: The transport blocks for PDSCH transmissions under the same HARQ Process with HARQ-ACK feedback may be the same, thereby still allowing for HARQ gains, even when HARQ feedback is be disabled.Proposal 4: For Type-1 HARQ codebook the codebook size should not be depending on the configuration for HARQ-ACK feedback (feedback enabled or disabled).Proposal 5: For Type-2 HARQ codebook the codebook size should not be depending on the configuration for HARQ-ACK feedback (feedback enabled or disabled).Proposal 6: For Type-3 HARQ codebook the codebook size should not be depending on the configuration for HARQ-ACK feedback (feedback enabled or disabled).Proposal 7: Do a down-selection of the options for indication of HARQ process ID such that only one option is specified. Proposal 8: Enhanced HARQ process ID indication is supported for DCI 0-2/1-2 and DCI 0-1/1-1 by extending the HARQ process ID field up to 5 bits when configuredProposal 9: Assign one additional bit for indicating the MSB of the HARQ process ID for DCI format 0-0 and DCI format 1-0Proposal 10: UEs supporting NTN should by default support the maximum number of HARQ processes to ensure network efficiency. |
| R1-2101385Apple | Proposal 1: Enhanced HARQ process number indication is supported for DCI 0-2/1-2 and DCI 0-1/1-1 by down-selecting between extending the HARQ process number field up to 5 bits and reusing one bit from another bit field.Proposal 2: Enhanced HARQ process number indication is supported for DCI 0\_0 and DCI 1\_0 by reusing one bit from another DCI bit field (e.g., RV field). Proposal 3: Support to have different configurations for HARQ processes with or without HARQ feedback. Proposal 4: Support blind PDSCH and PUSCH retransmissions for NTN. Proposal 5: In type-1 HARQ-ACK codebook construction, UE does not reduce the HARQ-ACK codebook size for HARQ processes with disabled HARQ feedback.Proposal 6: In type-2 HARQ-ACK codebook construction, reduce the codebook size for HARQ processes with disabled feedback.* In DCI of PDSCH with feedback enabled HARQ processes, the C-DAI and T-DAI are given their true values.
* In DCI of PDSCH with feedback disabled HARQ processes, the T-DAI is given its true value and C-DAI is given a reserved value.

Proposal 7: For type-1 HARQ-ACK codebook only for SPS PDSCH and for type-2 HARQ-ACK codebook for SPS PDSCH, consider whether/how to support the case where SPS configuration includes HARQ processes with different HARQ feedback settings.Proposal 8: For a downlink HARQ process with disabled feedback, a UE is not expected to receive another PDSCH or set of slot-aggregated PDSCH scheduled for the given HARQ process that starts until $T\_{proc,1}$ after the end of the reception of the last PDSCH or slot-aggregated PDSCH for that HARQ process. |
| R1-2101466Qualcomm | Observation 1: Within a lookback window of size $N$ (corresponding to a PUCCH occasion), for up to $M (M<N)$ PDSCHs of HARQ processes with feedback enabled (in any of the $N$ candidate occasions), $1+\sum\_{i=0}^{M-1}\left(\genfrac{}{}{0pt}{}{N}{i}\right) $codepoints are sufficient to construct a lossless semi-static ACK/NACK codebook.Proposal 1: When 32 HARQ processes is configured, UE determines the HARQ ID as 16\*mod(n,2) +k where* n is the slot number during which the DCI was first transmitted
* k is indicated by the 4 HARQ process ID bits in DCI

Proposal 2: For a DL HARQ process with disabled HARQ feedback, the UE is not expected to receive another PDSCH or set of slot-aggregated PDSCH scheduled for the given HARQ process that starts until X after the end of the reception of the last PDSCH or slot-aggregated PDSCH for that HARQ process.* X=max(Tproc,1, Tslot\*k) where k is the minimum of minimum of  dl-DataToUL-ACK if configured and 0 otherwise.

Proposal 3: Consider new CQI BLER targets for HARQ processes without feedbacks.Proposal 4: Support a new UCI feedback for reporting DL transmission disruption and/or requesting DL scheduling changes when HARQ feedback is disabled. * To study the new UCI format and associated resource allocation.

Proposal 5: For DL HARQ processes with HARQ feedback disabled, initial transmissions shall use RV 0 and retransmissions shall not use RV 0.Proposal 6: For Type-2 HARQ codebook* Only HARQ-ACKs of PDSCHs of HARQ processes with feedback enabled are included in the codebook
* Only PDSCHs of HARQ processes with feedback enabled are counted in DAIs in DCI.

Proposal 7: For semi-static HARQ ACK codebooks, within a lookback window of size $N$ PDSCHs candidate occasions, a UE may be scheduled with up to $M (M<N)$ PDSCHs of HARQ processes with feedback enabled, where the PDSCHs may be scheduled in any of the $N$ candidate position(s) within the lookback window.* The value of $M$ as a function of N are to be configured for the UE.

Proposal 8: RAN1 to consider semi-static HARQ codebook designs for limited PDSCH candidate occasions of HARQ processes with feedback enabled, with the aim of reducing the codebook size.Proposal 9: Support different transmit parameters and/or configurations per HARQ process or per HARQ process type (retransmissions is enabled/disabled), including* Power control
* MCS table
* UCI multiplexing parameters
* FFS other parameters

Proposal 10: For NTN, UE may receive a DCI scheduling a PUSCH of a given HARQ process before the end of the transmission of another PUSCH of that HARQ process. Proposal 11: Define a minimum time gap between two PUSCHs of a HARQ process. |