3GPP TSG RAN WG1 #103e-E R1-200xxxx

e-Meeting, October 26th – November 13th, 2020

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 meeting, agreements w.r.t the extension of HARQ process number and enabling/disabling on HARQ feedback for downlink transmission have been made. 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
* Restriction on HARQ feedback disabling
* Performance enhancements
* PDSCH/PUSCH scheduling restriction

# **Enhanced HARQ process ID indication**

According to the agreement in last meeting, the maximal supported HARQ process number is extended to 32. Detailed solutions are proposed in [Huawei, CAICT, Apple, vivo, CMCC, Intel, Xiaomi, CATT, Panasonic, Ericsson, QC, Sony, Lenovo, Spreadtrum, LG, ZTE, OPPO] with following options:

* **Option 1**: Slot index as the MSB [QC,HW, Sony, Lenovo]

In this option, the slot index is interpreted as MSB for HARQ ID calculation along with the indicated HARQ ID in existing DCI field.

* **Option 1-a:** Slot index as the LSB [CMCC, ZTE]

In this option, the slot index is interpreted as LSB for HARQ ID calculation along with the indicated HARQ ID in existing DCI field.

* **Option 2**: Reusing one bit from other bit field [CATT, CMCC, Apple, VIVO, ZTE]

In this way, one bit from other bit field is interpreted for HARQ ID calculation along with the indicated HARQ ID in existing DCI field.

* **Option 3**: Extending the HARQ process ID field up to 5 bits [Ericsson, Panasonic, CAICT]

In this option, the existing HARQ process ID field is extended to 5 directly.

* **Option 4**:CCE index associated [LG]

In this option, the determination of HARQ process ID will be coupled with the index of CCE, which carrying the scheduling information for transmission.

* **Option 5**: Additional scrambling for scheduling grant [Spreadtrum]

In this option, the determination of HARQ process ID will be up to additional scrambling on the scheduling grant.

* **Option 6**: DM-RS index associated [HW]

In this option, the determination of HARQ process ID will be coupled with the DM-RS index, which is associated to the transmission.

Moreover, [Intel] is supportive to associate the HARQ ID determination with slot index, but without detailed proposals. [OPPO, Xiaomi] highlights that the solution with lower DCI overhead, e.g., unchanged size is preferred. Meanwhile, as mentioned in [CMCC], extension of HARQ process ID field up to 5 is only used for DCI 0-2/1-2.

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

***[Initial Proposal 1]:*** *Enhanced HRAQ process ID indication is supported by at least one of 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*

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| **Company** | **Comments and Views** |
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In addition, w.r.t the supports for larger HARQ process number, [Samsung, CMCC, OPPO, Apple, MTK, Xiaomi, Asia Pacific Telecom, IDC] prefer to define it as optional UE capability. And [Ericsson, ZTE] highlight that larger HARQ process number is only enabled via the RRC configuration.

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

***[Initial Proposal 2]*** *Support on the maximal HARQ process number is up to UE capability.*

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# **HARQ codebook enhancements**

In RAN1#102e, preliminary discussion on the potential enhancements for HARQ codebook are conducted. In this meeting, views from companies are provided on this aspect. More specifically:

1. W.r.t the Type-1 Codebook (semi-static codebook):

The enhancement for Type-1 codebook is highlighted by [HW, VIVO, ZTE Samsung, Sony, Ericsson]. More specifically, the codebook size will be reduced by skipping the HARA-ACK feedback for disabled HARQ process. For example, the skipping can be conducted according to the indication (e.g., bitmap) from gNB [Samsung] or if all transmissions within same slot [ZTE] or all slots [vivo] are scheduled with disabled HARQ feedback. Also, improvement on the feedback overhead may also be achieved via different TDRA configuration as mentioned by [Sony].

However, as highlighted in [OPPO, CATT, Apple], enhancements on Type-1 is unnecessary.

1. W.r.t the Type-2 Codebook (Dynamic codebook):

The enhancement for Type-2 codebook is highlighted by [CATT, Samsung, OPPO, Sony, Apple, Intel, Asia Pacific Telecom, CAICT, QC]. More specifically, for example, the codebook size will be reduced by directly without counting DAI for the scheduling via HARQ process with disabled feedback [Ericsson]. But, to ensure the error correction capability [Asia Pacific Telecom, ZTE], one additional parameter (e.g., to count the number of scheduling with enabled feedback) can be considered to construct the codebook [ZTE].

1. W.r.t the enhanced Type-2 (Enhanced Dynamic Type-2) and Type-3 Codebook (Oneshot-feedback):

For these two cases, enhancements are not preferred by [CATT, Samsung, Apple, Intel, ZTE, and CAICT] since such functionalities are introduced only for unlicensed spectrum (i.e., shared spectrum) [Samsung, ZTE]. But, [Ericsson] highlights that it is also beneficial to improve it.

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

***[Initial Proposal 3]:*** *Enhancement on Type-1 and Type-2 HARQ codebook is supported.*

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# **Restriction on HARQ feedback disabling**

In addition to the agreement that disabling of HARQ feedback is done per UE per HARQ process via RRC, for ensuring the efficiency and reliability of transmission carrying the signalling, e.g., RRC configuration/MAC CE command, as highlighted in [CATT, Sony, MTK, ZTE, Ericsson], at least one HARQ process with feedback should be kept. Meanwhile, w.r.t the SPS release, the corresponding feedback should also be kept [Sony]. W.r.t the corresponding specification impact, down selection between following two options are proposed in [Ericsson]:

* *Option 1: UE expects that at least one HARQ process is configured with UL HARQ feedback;*
* *Option 2: 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.*

Meanwhile, LS with RAN1’s recommendation to inform RAN2 is proposed by [ZTE].

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

***[Initial Proposal 4]:*** *UE expects that at least one HARQ process is configured with HARQ feedback.*

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| **Company** | **Comments and Views** |
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# **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)

For this aspect, view from 12 companies are elaborated with corresponding enhancements mainly includes:

* + Value of aggregation factor:

As highlighted by [vivo, CATT, CMCC, MTK, ETRI, Ericsson, ZTE, Spreadtrum, Lenovo], supports of the larger aggregation factor is beneficial for NTN.

* + Indication of aggregation factor:

[CMCC, Lenovo] prefer to introduce different configurations for the transmission via HARQ process with enabled or disabled feedback. But, the unified parameters configuration is preferred by [CATT].

Meanwhile, DCI based indication for the repetition/aggregation related information is mentioned by [HW, Samsung]. More specifically, enhancement under the Rel-16 framework (e.g., numberOfRepetitions-r16 included in TDRA configuration)) is preferred by [Samsung].

* + Transmission scheme:

In case of supports on larger aggregation factor, the time-interleaved transmission is mentioned in [CATT, CMCC, vivo]. 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.

1. Enhancements on MCS (including CQI report)

For this aspect, view from 8 companies are elaborated with corresponding enhancements mainly includes:

* + Different MCS table configuration:

[vivo, Ericsson] prefer to introduce different configurations of MCS table in TBS determination for transmission via HARQ process with enabled or disabled feedback. But, the unified parameters configuration is preferred by [CATT, Lenovo, ZTE].

* + CQI report:

A new CQI table with larger BLER e.g., 1% [IDC] is proposed by [Thales, IDC, Qualcomm]. But this part is not preferred by [ZTE] since similar performance can be achieved by implementation of scheduling.

1. Blind retransmission

As highlighted by [Nomor Research GmbH, Thales, IDC, Spreadtrum, 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. But as highlighted by [CATT], the gain for blind retransmission is not clear and also from [ZTE] perspective, this solution can be conducted by implementation once the time domain scheduling restriction for PDSCH with same HARQ process is updated.

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., long CSI periodicity [Thales, Nomor Research GmbH], RV limitation for scheduling [QC] is proposed.

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)*

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| Ligado | Per <https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2008802.zip> we have demonstrated significant performance gains arising from adaptive blind repetitions (ABR) based on CQI feedback, specifically in NTN where channel blockage is a larger concern than multipath fading. Ligado commends this analysis to companies. The assertion [CATT] that the gain for blind repetition is not clear does not consider the adaptive aspect. ABR should at least be considered for further study. |
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# **PDSCH/PUSCH scheduling restriction**

In existing specification following restrictions are considered for the PUSCH and PDSCH scheduling with same HARQ process ID, respectively:

**PUSCH**

*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.*

**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...*

To enable the scheduling flexibility via the HARQ with disabled feedback, views on the PDSCH/PUSCH scheduling are elaborated below:

1. PDSCH:

[Ericsson] propose to update the restriction as: *For a DL HARQ process with disabled HARQ feedback, the UE is not expected to receive another PDSCH for the given HARQ process until after the end of the expected reception of the last PDSCH for that HARQ process.*

[OPPO] propose to update the restriction with consideration a new scheduling constraint to ensure enough PDSCH processing time between two PDSCH receptions with same HARQ ID.

1. PUSCH:

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

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

***[Initial Proposal 6]:*** *Following principle is supported for the PDSCH scheduling via same HARQ process with disabled feedback:*

* *For a DL HARQ process with disabled HARQ feedback, the UE is not expected to receive another PDSCH for the given HARQ process until after the end of the expected reception of the last PDSCH for that HARQ process.*

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| **Company** | **Comments and Views** |
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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 |
| R1-2007571 Huawei | Observation 1: HARQ ID can be implicitly indicated via slot index at the cost of scheduling flexibility.Observation 2: HARQ ID can be implicitly indicated via DMRS at the cost of false alarm ratio loss.Proposal 1: The following mechanisms for implicit indication of HARQ process ID can be considered.* Option 1: Associate HARQ process ID with slot index;
* Option 2: Associate HARQ process ID with DMRS sequence;

Proposal 2: The Type-1 HARQ-ACK codebook size can be reduced by skipping the HARQ-ACK feedback for disabled HARQ processes.Proposal 3: Transmission parameters shall be configurable and indicated via DCI.Proposal 4: Reinterpreting idle bits in DCI for indicating transmission parameters shall be considered.Proposal 5: UE assistance information reporting in reserved resource can be considered for NTN. |
| R1-2007662vivo | Observation 1: Considering different target BLER MCS tables for different use cases is benefit to NTN.Observation 2: Consider time interleaved slot aggregation for NTN.- the slot interval depends on the traffic packet size and transmission scheme.Observation 3: Considering different MCS tables and different aggregation factors for different NTN scenarios is benefit to NTN.Proposal 1: Support re-interpreting existing DCI field to indicate the extension of HARQ process number for NTN.Proposal 2: Support different MCS tables and different aggregation factors for different NTN use cases and scenarios.Proposal 3: At least one enabled HARQ process should be configured for NTN.Proposal 4: Support to report HARQ-ACK for disabled DL HARQ processes if enabled HARQ process(es) is within the  occasions for type-1 HARQ-ACK codebook. |
| R1-2007856CATT | 1. At most 32 HARQ processes can be supported without UE capability report if only single layer transmission is assumed in NTN.
2. Specify supported HARQ process number for fallback case.
3. Re-interprete DCI field to indicate 32 HARQ indexes.
4. Keep at least one HARQ process with feedback if UE specific disabling is configured.
5. A unified solution of configuration parameter is preferred for with and without HARQ .
6. Support more than 8 repetitions in slot-aggreation transmission.
7. No optimization is needed for type 1 HARQ-ACK codebook and no touch on type 3 HARQ-ACK codebook.
8. Type 2 HARQ-ACK codebook can be optimized for NTN from saving overhead perspective.
9. Blind retransmission is not supported in NTN case.
10. Slot aggregation factor can be extended to 16 for very low SINR case.
11. Support time interleaved slot aggregation to improve transmission reliability.
12. No need to define a minimum time gap for without HARQ-ACK feedback case if blind retransmission is not supported.
13. Blind retransmission doesn’t show clear benefits over slot aggregation but with redundant DCI indication.
14. Define a minimum time gap between two PDSCHs of a HARQ process without HARQ-ACK feedbacks，which is necessary only for the blind retransmission.
15. There is no need for the enhancement on HARQ feedback.
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| R1-2008012CMCC | Proposal 1: Support DCI format 0\_2 and 1\_2 with up to 5 bit HARQ process number field as configured by higher layer parameter.Proposal 2: The following solutions for up to 32 HARQ process ID indication can be further studied* Re-interpretation of existing DCI field
* Slot/SFN-based solution with LSB value for HARQ ID determined by time information.

Proposal 3: Support different configuration on aggregation factor for HARQ process with/without feedback.Proposal 4: Support larger aggregation factor in NTN.Proposal 5: Support on the maximal HARQ process number is up to UE capability. |
| R1-2008166Samsung | 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 to indicate the number of repetitions.

Proposal 6: For the maximum number of HARQ processes, consider 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 7: UE assistance information for HARQ should be studied for NTN. |
| R1-2008255OPPO | Proposal 1: The enabling/disabling of HARQ processes for both DL and UL scheduling via RRC or DCI should be supported.Proposal 2: HARQ-ACK information for disabled DL HARQ processes should be reported at least in Type-1 HARQ-ACK codebook and FFS in Type-2 HARQ-ACK codebook.Proposal 3: Support on the maximal HARQ process number is up to UE capability. Proposal 4: Low DCI overhead methods should be considered if the number of HARQ processes is 32. Proposal 5: Enhancements to PDSCH/PUSCH with disabled HARQ process to achieve a higher reliability should be considered. Proposal 6: PUSCH processing time should be updated in NTN. Proposal 7: PDSCH reception constraint for a given enabled DL HARQ process should be enhanced in NTN. Proposal 8: PDSCH reception constraint for a given disabled DL HARQ process should be considered in NTN. Proposal 9: PUSCH transmission constraint for a given enabled UL HARQ process should be enhanced in NTN. Proposal 10: PUSCH transmission constraint for a given disabled UL HARQ process should be considered in NTN.  |
| R1-2008361Sony | Observation 1: The beam switching is a time-sensitive behavior due to the movement of satellite. Waiting for the HARQ feedback for PDSCH carrying MAC CE for beam switching may miss the favorable time.Observation 2: The redundant feedback of Type-1 / semi-static HARQ codebook would be large based on current HARQ codebook design.Proposal 1: Support slot-based HARQ process ID indication when maximal supported HARQ process number is extended to 32.Proposal 2: Support at least one HARQ process with HARQ feedback enabled.Proposal 3: When the MAC CE for beam switching is carried by PDSCH without HARQ feedback. UE applies the corresponding action with the reference to slots of the end of PDSCH transmission.Proposal 4: At least adjustment for HARQ codebook Type-1 and Type-2 should be considered.* Enhancement on Type-1/ Semi-static HARQ codebook to reduce the redundant feedback should be studied. Following method can be considered:
	+ Separate TDRA table configuration for HARQ process with HARQ-ACK disabling and HARQ-ACK enabling.
* DAI is not incremented for a PDCCH which is scheduling a HARQ process with HARQ-ACK disabling.

Proposal 5: When the HARQ process of SPS PDSCH is HARQ feedback disabled, UE reports HARQ feedback information for the SPS PDSCH activation.  |
| R1-2008412LG | Proposal 1: The maximum number of HARQ process is up to UE capability. Proposal 2: Consider CCE index based HARQ process id identification for NTN.Proposal 3: FFS on the use case and clear benefit of dynamic HARQ enabling/disabling. Proposal 4. Consider recommended repetition factor, PDSCH decoding results or probability as new CSI contents.Proposal 5: Consider HARQ-ACK codebook enhancement when HARQ feedback is disabled. |
| R1-2008467 Apple | Proposal 1: Supporting the maximal HARQ process number of 32 is up to UE capability.Proposal 2: Consider always applying LBRM for UE operating with 32 HARQ processes.Proposal 3: The HARQ process number field in DCI is remained to be 4 bits, and DCI fields are re-interpreted to indicate up to 32 HARQ process numbers. Proposal 4: Support to have different configurations for HARQ processes with or without HARQ feedback. Proposal 5: Support blind PDSCH and PUSCH retransmissions for NTN. Proposal 6: In type-1 HARQ-ACK codebook construction, UE does not reduce the HARQ-ACK codebook size for HARQ processes with disabled HARQ feedback.Proposal 7: In type-2 HARQ-ACK codebook construction, UE does not expect to receive increased counter DAI for HARQ processes with disabled HARQ feedback.  |
| R1-2008810MTK | Proposal 1: Support of 32 HARQ processes in the device is a UE capability in NR NTN.Observation 1: To improve reliability in case UL HARQ feedback is disabled via configuration, faster ARQ re-transmissions over the RLC layer could be configured – e.g. every 5 ms, 10 ms, 15 ms, 20 ms, ... Observation 2: Reliability of Message 3 in RACH procedure cannot be achieved via RLC ARQ as RLC AM is not possible before contention resolution has completed.Proposal 2: UL HARQ retransmissions is not disabled for Message 3 transmission in RACH procedure.Proposal 3: Whether UE should expect that at least one HARQ process is configured with UL HARQ feedback for MAC CE activation / de-activation is specified or up to network configuration.Proposal 4: The HARQ parameters for HARQ processes with enabling/disabling on HARQ feedback for downlink transmission can be configured differently to ensure adequate reliability – i.e. Block error rate target, MCS table, aggregation factor, Time Domain and Frequency Domain resource allocation, PRB bundling, etc.Proposal 5: The network can configure one HARQ process pool with UL HARQ feedback enabled and one HARQ process pool with UL HARQ feedback disabled. Proposal 6: Whether HARQ process IDs with UL HARQ feedback disabled via RRC can do HARQ soft combining is a UE capability.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. Observation 4: An SNR gain in the order of 1 dB is required to achieve a BLER target of e-3 compare to BLER target of e-1 in TDL-D channel profile in NR NTN. This represents less than a CQI step for the gNB scheduler. Proposal 7: Higher level of slot aggregation / repetitions than 8 is FFS |
| [R1-2008852](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_103%5CDocs%5CR1-2008852.zip)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: LS to RAN2 is recommend to capture the identified impacts (along with RAN1’s suggestions) on scheduling due to disabled HARQ feedback.**Proposal 3: Enhancement on the Type-1/2 codebook can be considered.**Proposal 4: Enlarged aggregation factor and reduced DM-RS density should be supported to improve the performance for NTN.**Proposal 5: 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*
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| [R1-2008881](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_103%5CDocs%5CR1-2008881.zip) Nomor Research GmbH, Thales | Observation 1: Considering 15UEs per cell, the DL UE throughput is similar for 16 and 32 HARQ processes if a restriction to schedule less than 4UEs per TTI is applied.Observation 2: Considering 15UEs per cell with a restriction to schedule up to 4UEs per TTI, the 50%-tile DL UE throughput is 7% higher, if up to 32 instead of 16 HARQ processes can be configured per UE.Observation 3: Increasing the number of UEs per cell from 15 to 20, the difference of the DL UE throughput between systems where up to 16 or 32 HARQ processes per UE can be configured disappears.Observation 4: Considering 15UEs per cell with a restriction to schedule up to 3UEs per TTI, the 50%-tile UL UE throughput is 11% higher, if up to 32 instead of 16 HARQ processes per UE are used.Observation 5: Considering 20UEs per cell with a restriction to schedule up to 3UEs per TTI, the 50%-tile UL UE throughput is 9% higher, if up to 32 instead of 16 HARQ processes can be configured per UE.Observation 6: Considering 30UEs per cell the with a restriction to schedule up to 3UEs per TTI, the CDF of the UL UE throughput is similar if up to 32 or 16 HARQ processes can be configured per UE.Observation 7: If the propagation delay decreases, e.g. for a system using a lower orbit, the round trip time decreases and 16 HARQ processes per UE will be sufficient. Observation 8: The main purpose of NTN is to provide coverage everywhere and to support high mobility. In real NTN scenarios, there is no need to schedule a UE in each TTI.Observation 9: Considering a GEO Ka-Band scenario with FR3 and 10 LOS UEs per cell, the TP per UE is on average 30% lower (8.8Mbit/s vs. 12.6Mbit/s) if link adaptation is performed based on the instantaneous channel state.Observation 10: Considering a GEO Ka-Band scenario with FR3 and 10 LOS UEs per cell, the probability of an RLC error rate per UE larger than 3% is 4% if link adaptation is performed based on the instantaneous channel state and BLER offset, while it is 0.6% if link adaptation is performed based on initial channel state measurement and BLER offset.Observation 11: Considering a GEO Ka-Band scenario with FR3 and 10 LOS UEs per cell, it is useful to do an averaging in terms of BLER rather than taking into account the instantaneous channel state due to the expiration of the channel state information upon receiving the CQI at the gNB because of the large transmission delay.Observation 12: Applying a CQI feedback with 1% PHY BLER target performs better in terms of TP than applying a CQI feedback with 10% PHY BLER target and an additional offset.Observation 13: The probability of an RLC error rate per UE larger than 2% is 0.8% if a PHY BLER target of 1% is applied and 0.5% if an averaged SINR in dB and an offset of -4.5dB is used for link adaptation. In the other considered cases of averaged SINR the RLC error rate is significantly larger.Observation 14: Considering a GEO Ka-Band scenario with FR3 and 10 LOS UEs per cell, the mean TP per UE increases from 13.2Mbit/s to 14.0Mbit/s if a PHY BLER target of 2% instead of 1% is applied.Observation 15: Considering a GEO Ka-Band scenario with FR3 and 10 LOS UEs per cell, the 5%-tile of the TP per UE increases from 8.4Mbit/s to 9.2Mbit/s if a PHY BLER target of 2% instead of 1% is applied.Observation 16: Considering a GEO Ka-Band scenario with FR3 and 10 LOS UEs per cell, the mean RLC error rate per UE increases from 1.1% to 2.2% if a PHY BLER target of 2% instead of 1% is applied.Observation 17: Considering a GEO Ka-Band scenario with FR3 and 10 LOS UEs per cell, the 5%-tile of the RLC error rate per UE increases from 0.8% to 1.8% if a PHY BLER target of 2% instead of 1% is applied.Observation 18: The specified 5QI match either packet error rate or delay of a GEO scenario but not both. Proposal 1: The support of 32 HARQ processes is up to UE capability.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: Introduce larger CSI-Report periodicity values in TS 38.331 to avoid unnecessary overhead in scenarios with large transmission delay.Proposal 4: Introduce a target BLER for CQI-Reporting to support NTN scenarios with HARQ disabled. Proposal 5: RAN1 to discuss reasonable assumptions for operator defined 5QI requirements to support GEO satellite communication in NR. |
| R1-2008924,Lenovo, Motorola Mobility | Proposal 1: The HARQ process number is tied to SFN/slot index of PDCCH/PUSCH/PDSCH.Proposal 2: Different numbers of HARQ processes is configured based on UE capability.Proposal 3: UE assumes the HARQ feedback disabling where HARQ ID belongs to the RRC configured HARQ process disabling subset.Proposal 4: The multiple transmissions of same TBs in consecutive or interlaced slots can be considered when HARQ is disabledProposal 5: Repetition transmission number and interlace transmission interval can be indicated in corresponding DCI when HARQ process disabling.Proposal 6: A unified configuration should be considered for each HARQ process with/without feedback except aggregation factor if benefit identified. |
| R1-2008991 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: * If 32 parallel HARQ processes are supported for NTN,
	+ HARQ process ID is determined based on DCI indication and slot index of the corresponding transmission
		- 4 bits are used for HARQ process ID indication in DCI
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| R1-2009017ETRI | 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 (SC4,19,20), the DL geometry SINR range might be from -6 dB (5%) to 1 dB (95%).

Observation 2 : Under the worst NTN scenario, S(I)NR might be narrower and lower than TN.* For all cases(SC4,5,19,20), 90 % (between 5% and 95%) of the links are concentrated within 4 dB
* For SC5, 95 % of the links are below 5 dB.
* For other cases (SC4,19,20), 95 % of the links are below 1 dB.

Observation 3 : Within low S(I)NR region, the slot aggregation could enhance BLER and SE simultaneously.Observation 4 : The slot aggregation might have shorter latency than HARQ retransmission.Observation 5 : The slot aggregation has no specification impact.Observation 6 : If aggregation factor is determined properly, the optimal channel adaptation between BLER and SE might be possible. * The transmission parameter should be determined properly.
	+ Too reliable parameter : throughput loss
	+ Proper parameter : optimal adaptation
	+ Too un-reliable parameter : reliability/latency loss (might be unable to communicate)

Observation 7 : The appropriate aggregation factor value might be varying depending on the channel condition and the target performanceObservation 8 : In NR, if the slot aggregation is used, gNB cannot distinguish between just proper parameter and too reliable parameter. * 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 9 : In NR, If the slot aggregation is used, gNB cannot optimally react to some cases.* 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 10 : In NR, there is no feedback mechanism to guide AF into lower value for better throughput* Once the AF value gets larger, it may be impossible to be reduced again

Observation 11 : If all the HARQ feedback are disabled, gNB might have no HARQ feedback.Observation 12 : 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 13 : 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

Observation 14 : Each parameter (especially IMCS) has its own optimal aggregation factor value.Observation 15 : For optimal adaptation, different aggregation factor should be applied depending on the parameter (especially IMCS)Observation 16 : The optimal aggregation factor might be different, depending on the target performance.Observation 17 : For optimal adaptation, different aggregation factor should be applied depending on the target performance.Observation 18 : In NR, various kinds of transport channels are multiplexed into PDSCH/PUSCH.* Each transport port channel might have its own transmission purpose (target performance).
* Transport channel might be distinguishable by checking the RNTI type of PDSCH/PUSCH
	+ PDSCH related RNTI : {P,SI,RA,MSGB,TC,C,MCS-C,CS}-RNTI
	+ PUSCH related RNTI : {TC,C,MCS-C,CS}-RNTI

Observation 19 : In NTN, different target performance might be defined by the HARQ feedback availability.Proposal 1 : Consider the slot aggregation (“larger aggregation factor”) as the solution for “#Issue 4: Enhancement on the transmission” in [5].Proposal 2 : Consider the UCI for scheduling change request as the solution for both “6.4 #Issue 4: Enhancement on the transmission” in [5] and the adaptation feasibility issue described in this paper.* UCI can include information such as
	+ request for increasing/decreasing pdsch-AggregationFactor
	+ request for increasing/decreasing MCS
	+ DL decoding statistics
	+ combinations 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 3 : Consider “Introducing the separate aggregation factors depending on followings” as the solution for “6.2 #Issue 2: Mechanism for disabling/enabling HARQ feedback” in [5].* (a group of) MCS index
* (a group of) RNTI type (or search space)
	+ PDSCH related RNTI : {P,SI,RA,MSGB,TC,C,MCS-C,CS}-RNTI
	+ PUSCH related RNTI : {TC,C,MCS-C,CS}-RNTI
* HARQ feedback availability (enabled/disabled)
	+ (a group of) HARQ process number
* combinations of the above
* subsets of the above
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| R1-2009034Xiaomi | Proposal 1: The number of supported HARQ processes is subject to the UE’s capability.Proposal 2: The length of the HARQ process indicator bit-field in the scheduling grant should be kept unchanged. Proposal 3: Dynamic HARQ enabling/disabling is not supported.Proposal 4: Enhancement on the UCI reporting such as the data decoding statistics should be introduced. |
| R1-2009050Panasonic | Proposal 1: The maximum number of HARQ processes for NTN is 32. Proposal 2: 1 bit is added for HARQ process ID indication in DCI format 0\_1, 1\_1 and 0\_2, 1\_2. Proposal 3: Enhancement of PDSCH/PUSCH transmission to improve user throughput without further increasing the number of HARQ processes should be discussed.Proposal 4: Transport block size scaling in case of repetition should be supported to improve user throughput with a limited number of HARQ processes.  |
| R1-2009059Asia Pacific Telecom | Proposal 1 Support on the maximal HARQ process number is up to UE capability.Proposal 2 More than 16 HARQ shall only be supported by VAST and mounted devices.Proposal 3 RAN1 impact on HARQ UL retransmission enabling/disabling shall be discussed.Proposal 4 Timing enhancement on the Type-1 HARQ-ACK codebook shall be needed.Proposal 5 HARQ-ACK disabling shall not change the Type-1 HARQ-ACK codebook size.Proposal 6 Timing enhancement on the Type-2 HARQ-ACK codebook shall be needed.Proposal 7 DAI enhancement on the Type-2 HARQ-ACK codebook shall ensure the error correction capability. |
| R1-2009078CAICT | *Proposal 1: Support up to 32 HARQ processes indication with one additional bit field in the DCI.**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.* |
| [R1-2009093](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_103%5CDocs%5CR1-2009093.zip)Ericsson | 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 or 0\_2/2\_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 The intention of disabling HARQ feedback for a downlink transmission is not to send HARQ feedback for the downlink transmission.Observation 5 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 6 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 7 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 8 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 RAN1 to down select one option: Option 1 – UE expects that at least one HARQ process is configured with UL HARQ feedback; Option 2 – 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. Example parameters include MCS table and 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 UE ignores counter DAI from a PDCCH that is associated with a feedback disabled HARQ process and counter DAI is not incremented for such a PDCCH.Proposal 9 When HARQ processes are enabled/disabled on a per HARQ process basis, in the case of the NR Type-2 HARQ codebook, the total DAI (if present) indicates the sum of all the scheduled PDCCHs associated with feedback enabled HARQ process.Proposal 10 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 11 Keep the existing uplink HARQ process reuse rule.Proposal 12 For a DL HARQ process with disabled HARQ feedback, the UE is not expected to receive another PDSCH for the given HARQ process until after the end of the expected reception of the last PDSCH for that HARQ process. |
| R1-2009118IDC | *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 layer**Observation-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 disabled**Observation-3: increasing the maximum HARQ process number could provide benefits in terms of higher throughput, low latency, better resource utilization over HARQ feedback disabling scheme when channel/interference changes dynamically**Observation-4: increasing the maximum HARQ process number is desirable only for some type of UEs (e.g., VSAT)**Proposal-1: a CQI table with a new target BLER (e.g., 1%) is considered when HARQ feedback is disabled**Proposal-2: blind retransmission is considered when HARQ feedback is disabled**Proposal-3: support maximum 32 HARQ process number as UE optional feature* |
| R1- 2009154Spreadtrum | Proposal 1: Additional scrambling for scheduling grant should be considered for enhancement on HARQ process number.Proposal 2: Blind retransmission and larger aggregation/repetition factor can be considered for enhancing the performance of transmission. |
| R1-2009244Nokia | Observation 1: According to [4], disabling HARQ may achieve similar throughput compared to increasing the number of HARQ processes.Observation 2: According to [5], using 16 or 32 DL HARQ processes will give similar UE experience in most scenariosObservation 3: Using slot aggregation at low effective code rates will provide efficiency gains for cases with 2 or 4 slots being aggregated.Observation 4: Slot aggregation allows for supporting larger RTT delays while not compromising the HARQ performance.Proposal 1: Limit the maximum of HARQ processes for NTN to 16 to ensure minimum specification changesProposal 2: For operating NTN systems, mechanisms like HARQ process disabling and slot aggregation are sufficient means for addressing the HARQ stalling problem. |
| R1-2009264QC | Proposal 1: For NTN, UE reports the capability on the number of HARQ processes.Proposal 2: For NTN, more than 16 HARQ processes can be configured.Proposal 3: For NTN, support slot number based HARQ process identification when more than 16 HARQ processes are configured to a UE. Proposal 4: Define a minimum time gap between two PDSCHs of a HARQ process without feedbacks * Different numerologies may have different time gaps.
* FFS to introduce virtual k1.

Proposal 5: Consider new CQI BLER targets for HARQ processes without feedbacks.Proposal 6: 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 7: For DL HARQ processes with HARQ feedback disabled, initial transmissions shall use RV 0 and retransmissions shall not use RV 0.Proposal 8: For Type-2 HARQ codebook, only PDSCHs of HARQ processes with feedback enabled are considered in DAIs in DCI. Proposal 9: Support search space configuration per HARQ process type.Proposal 10: 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 11: 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 12: Define a minimum time gap between two PUSCHs of a HARQ process. |