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

**e-Meeting, May 10th – April 27th, 2021**

**Agenda item:** 8.15.4

**Source:** Moderator (Samsung)

**Title:** Summary#1 of enhancements on HARQ

**Document for:** Discussion and Decision

# Introduction

Studying aspects related to HARQ operation is one of the objectives of the Study on NB-IoT/eMTC support for Non-Terrestrial Network. In RAN#91-e it was discussed the prioritization of enhancements of essential features that can be considered in a potential normative phase in Rel-17.

From [RP-210915](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Docs/RP-210915.zip) in RAN1#91-e:

* *The study on IoT over NTN should target the following by RAN#92*
	+ *Detailed study of solutions addressing essential functionality for GEO and NGSO scenarios, prioritizing at least the use case of intermittent delay-tolerant small packet transmissions*
	+ *Prioritization of potential enhancements for the functionalities needed specifically for IoT over NTN that cannot be translated from the ongoing NR NTN WI for the considered scenarios and use case(s) in the study*
	+ *Recommendations on specification changes needed at least for essential functionality (to be determined by working groups targeting Rel-17), for the considered scenarios and use case(s)*
	+ *Note: Additional enhancements on at least the following can be considered by the working groups as candidates for non-essential functionality in Rel-17.*
		- *HARQ*
		- *Latency*
		- *Power consumption*
		- *Spectral efficiency*
		- *Coverage*
		- *Mobility*
		- *RLF and re-establishment handling*
* *Time permitting, at least a high-level description of the potential solutions for enhancements targeting potential optimization of IoT NTN in later releases can be captured in TR 36.763, when feasible.*

This contribution summarizes companies’ views for enhancements on HARQ.

# Discussion

## Disabling HARQ feedback

Disabling of HARQ feedback has been agreed in NR NTN: *Enabling/disabling on HARQ feedback for downlink transmission should be at least configurable per HARQ process via UE specific RRC signalling*. With this solution, no explicit UL feedback for DL transmission acknowledges a successful transmission and the HARQ process does not need to wait for the feedback before a new data transmission. This can avoid HARQ stalling and consequently throughput degradation. Correspondingly, retransmission at RLC layer (i.e. RLC ARQ) may be required to meet reliability requirements. Typically, ARQ re-transmissions in RLC can have high latency, which might be acceptable as IoT services are generally delay tolerant.

**Table 1 Views on disabling HARQ feedback**

|  |  |
| --- | --- |
| **Company** | **Input** |
| [R1-2104261](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102346.zip)Huawei,HiSilicon  | **Proposal** 1: Disabling HARQ processes is not necessary for IoT-NTN. |
| [R1-2104400](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102425.zip)Vivo | **Observation** 1: It can be up to network implementation to configure the enabling/disabling HARQ feedback for one HARQ process, and determine the number of disabled HARQ processes.**Proposal** 1: Support the functionality of disabling HARQ feedback for NB-IoT/eMTC over NTN.**Proposal** 2: The functionality of enabling/disabling HARQ feedback per HARQ process can be semi-statically configured and dynamically switched. |
| [R1-2104450](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102475.zip)Spreadtrum | **Proposal** 1: Whether to support disabling HARQ feedback for IOT NTN can be considered in R18. |
| [R1-2104506](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102551.zip)CATT | **Observation** 1: Disabling HARQ feedback doesn’t show clear benefit to NB-IoT NTN and CEmodeA eMTC use case.**Proposal** 1: Reuse disabling HARQ feedback mechansim of NR NTN for CEmodeB in eMTC NTN.**Proposal** 2: No enhancement in disabling HARQ feedback is needed for HARQ in NB-IoT NTN and CEmodeA eMTC over satellite. **Proposal** 3: Enabling/disabling on HARQ feedback for downlink transmission should be at least configurable per HARQ process via UE specific RRC signalling. |
| [R1-2104570](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102620.zip)MTK | **Observation** 1: for NB-IoT, HARQ stalling reduces data rates by approximately 95% and 49% for GEO and LEO respectively. **Observation** 2: for NB-IoT, HARQ can be used without disabling HARQ feedback with data rates consistent with sporadic short transmissions.**Observation** 3: for NB-IoT, the maximum latency with 2 HARQ processes with up to 4 HARQ transmissions is 2264 ms. **Observation** 4: for NB-IoT, HARQ can be used without disabling HARQ feedback with latency consistent with sporadic short transmissions.**Proposal** 1: HARQ feedback is not disabled in connected.**Proposal** 2: UL HARQ feedback is not disabled for Message 3 during initial access. |
| [R1-2104639](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102738.zip)CMCC | **Observation** 1: Disabling HARQ feedback is beneficial to throughput improvement and latency reduction.**Observation** 2: If reliable transmission is required, disabling HARQ feedback may increase the power consumption.* If HARQ feedback is disabled, higher repetition number may be configured, which may significantly increase the power consumption for DL data reception.
* If retransmission at RLC layer (i.e. RLC ARQ) is supported, UE may need to awake for a longer time to wait for the potential retransmission scheduling signaling trigged by RLC layer, which may increase the power consumption for PDCCH monitoring.

**Proposal** 1: The impact of disabling HARQ feedback on power consumption, as well as whether reliability reduction is acceptable in IoT NTN, needs further study. |
| [R1-2104780](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102757.zip)OPPO | **Proposal** 1: HARQ disabling for NB-IoT/eMTC over NTN should NOT be specified in Rel-17. **Proposal** 2: HARQ disabling and increased HARQ process number for NB-IoT/eMTC over NTN should be studied and specified in later release.  |
| [R1-2104817](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102834.zip)Ericsson | **Observation** 1 The current specification does not require the gNB to wait for reception of HARQ-ACK for a DL HARQ process before scheduling a new TB for that HARQ process. gNB can maintain downlink peak data rate by scheduling new TB for a given DL HARQ process immediately after the UE transmits the HARQ-ACK feedback.**Observation** 2 The current specification does not require the gNB to wait for reception of a TB for an UL HARQ process before scheduling a new TB for that HARQ process. The gNB can maintain uplink peak data rate by scheduling new TB for a given UL HARQ process immediately after the UE transmits the previous PUSCH.**Proposal** 1 RAN1 to conclude that, according to current specification, gNB can maintain downlink peak data rate by scheduling new TB for a given HARQ process without waiting for reception of the HARQ-ACK feedback of that HARQ process.**Proposal** 2 RAN1 to conclude that, according to current specification, gNB can maintain uplink peak data rate by scheduling new UL TB for a given HARQ process without waiting for reception of the previous TB of that HARQ process.**Observation** 3 When gNB schedules a new TB for a HARQ process without waiting for HARQ-ACK feedback reception of the same HARQ process, the HARQ-ACK feedback can still be beneficial for other purposes including outer-loop link adaption. |
| [R1-2104825](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102908.zip)Qualcomm | **Observation** 1: For GEO Set 1 deployments, not supporting any feedback disabled HARQ process(es) results in a throughput/latency penalty of > 11x for UEs with one HARQ process and > 5.5x for UEs with two HARQ processes.**Proposal** 1: RAN1 to support at least one feedback-disabled HARQ process for NB-IoT over NTN. FFS eMTC. |
| [R1-2105141](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102919.zip)Apple | **Observation** 1: Disabling HARQ feedback for downlink transmissions may increase throughput, at the cost of reduced reliability and increased latency. **Observation** 2: Disabling HARQ feedback for downlink transmissions does not increase the IoT device complexity and can reduce the power consumption. **Proposal** 1: Disabling HARQ feedback for downlink transmissions is supported for IoT over NTN. **Proposal** 2: Disabling HARQ feedback for downlink transmission is configurable per HARQ process via UE specific RRC signaling.  |
| [R1-2105196](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103063.zip)ZTE | **Proposal** 1: HARQ feedback disabling for DL only should be supported in IoT-NTN.**Proposal** 2: Dynamic configuration of HARQ feedback disabling should be supported in IoT-NTN.**Proposal** 3: Enhancement on UL HARQ to increase throughput is not needed in IoT-NTN. |
| [R1-2105348](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103073.zip)Samsung | **Proposal** 1: Disabling of HARQ feedback should be supported as NR NTN.**Proposal** 2: HARQ feedback can be enabled/disabled per HARQ process via UE specific RRC signaling as NR NTN.**Proposal** 3: Whether to support disabling of HARQ feedback for all the HARQ processes should be discussed. |
| [R1-2105407](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103135.zip)Nokia | **Observation** 1: repetition for IoT UE will mitigate the impact of HARQ stalling because of long propagation delay in NTN scenario.**Observation** 2: The UE may be able to provide early termination indication to the network to indicate when sufficient number of repetitions are received. **Observation** 3: HARQ feedback disabling is impacting link adaptation in some IoT NTN scenarios. **Proposal** 1: If HARQ feedback disabling is supported, alternative long-term feedback for HARQ, e.g. assistance on requested number of repetition, BLER-based triggering or bundling of feedback, should be considered to maximize the performance of the link. |
| [R1-2105553](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103269.zip)Xiaomi | **Proposal** 1: HARQ disabling is not supported for IoT NTN.  |
| R1-2105621Lenovo | **Proposal** 1: At least for NBIoT NTN, disabling HARQ is not supported, and for eMTC, especially CE mode A, disabling HARQ can be considered in Rel.18 due to limited time for this release. |
| R1-2105678InterDigital | **Proposal**-1: Disabling HARQ feedback is not supported in Rel-17 in IoT NTN**Proposal**-2:  |
| [R1-2105827](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103530.zip)APT,FGI,ITRI,III | [**Observation** 1 RAN2 has agreed that enable and disable HARQ feedback is R2 scope.](file:///C%3A%5CUsers%5Ccarmela.c%5CAppData%5CLocal%5CTemp%5CTemp1_R1-2105827.zip%5CR1-2105827%20Enhancements%20on%20HARQ%20to%20NB-IoT%20in%20NTN.docx#_Toc71202647)[**Observation** 2 In this release, the MAC entity can disable HARQ feedback by not indicating to the PHY layer.](file:///C%3A%5CUsers%5Ccarmela.c%5CAppData%5CLocal%5CTemp%5CTemp1_R1-2105827.zip%5CR1-2105827%20Enhancements%20on%20HARQ%20to%20NB-IoT%20in%20NTN.docx#_Toc71202648)[**Proposal** 1 Disabling HARQ feedback for NB-IoT over NTN is recommended not to be discussed in RAN1.](file:///C%3A%5CUsers%5Ccarmela.c%5CAppData%5CLocal%5CTemp%5CTemp1_R1-2105827.zip%5CR1-2105827%20Enhancements%20on%20HARQ%20to%20NB-IoT%20in%20NTN.docx#_Toc71202649) |

Summary of companies’ views:

* Disabling HARQ feedback (6)

Supported by: Vivo, CATT (only for eMTC CEModeA), ZTE, Qualcomm, Samsung, Apple

* No disabling of HARQ feedback (18)

Supported by: Huawei, HiSilicon, Oppo, CATT (for NB-IoT and eMTC CEModeB), APT, FGI, ITRI, III, MediaTek, Nokia, NSB, CMCC, Xiaomi, Interdigital, Lenovo, Motorola Mobility, Ericsson, Spreadtrum

Companies discussed the motivation for disabling HARQ feedback and the majority view is not to introduce it in NTN IoT. One company thinks that it is not necessary to introduce it for the purpose of maintaining uplink throughput in NTN because a gNB can ensure that by scheduling new UL TB for a given HARQ process without waiting for reception of the previous TB of that HARQ process. Some companies have concerns on the reliability of the downlink transmission due to the lack of feedback, while other companies are not convinced that there would be benefits for UE power consumption and/or latency if disabling HARQ is introduced. Other companies think that it should be introduced because it was already introduced in NR NTN and it would benefit UE power consumption, downlink throughput and latency.

Similar to proposals and discussions during RAN1#104b-e, the majority of companies proposes not to introduce disabling HARQ feedback for NTN-IoT. Considering companies’ inputs and that this is the last RAN1 meeting for this SI, it is the FL opinion that RAN1 may conclude not introducing this feature. Any further input is welcome, including comments on the analysis in [5] and [9].

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| **Company** | **Comments** |
| ZTE | In our contribution, we do see the benefits on the introduction of HARQ disabling for DL only. For IoT over NTN, for each transmission, the needs for disabling is highly up to the used repetition number. Moreover, since the available HARQ process number for IoT is limited and dynamic disabling is more preferred. From SI perspective, since there are strong interests from companies on this topic, it is better to capture the corresponding discussion and solutions in TR.  |
| Lenovo, MotoM | We support the FL proposal, due to limited available HARQ process number, it is not necessary to introduce the feature, especially for NBIoT and eMTC CEMode B.  |
| vivo | The motivation, benefits and concerns of disabling HARQ-ACK feedback are discussed a lot by companies. According to moderator views about the RAN1 meeting timing, if the majority does not want to introduce disabling HARQ feedback for NTN-IoT, we can agree not to introduce this feature in this release and can further study in future release.  |
| CMCC | We support the FL proposal. |
| OPPO | We think the feature of disabling HARQ feedback can be discussed in later release instead of R17 due to limited time.  |
| Huawei, HiSilicon | We agree with the moderator’s conclusion of not introducing the disabling of HARQ feedback at this stage. |
| MediaTek | Support moderator’s conclusion of not introducing the disabling of HARQ feedback in Release 17 timeframe. |
| Apple | Considering the benefits of reduced power consumption and increased throughput, we think disabling HARQ feedback for downlink transmissions can be supported in IoT over NTN.  |
| Novamint | We support the moderator’s conclusion of not introducing the disabling of HARQ feedback at this stage. |
| Nokia, NSB | Generally we agree not support HARQ feedback disabling in Rel 17 IoT NTN SI. However, we suggest to further study for different scenario with target requirements for NB-IoT and eMTC in normative phase, to check whether HARQ feedback disabling is not needed for all scenario/use cases. |
| Qualcomm | We have demonstrated in our contribution, that **we lose at least** **5.5x** (for UEs with 2 HARQ processes) and at least **11x** (for UEs with 1 HARQ process) **in throughput/latency** for GEO Set 1 deployments, if we don’t support this simple enhancement of disabling HARQ.1. This is **already supported for SC-PTM in NB-IoT**—we fail to understand what is the “extra work” in making this simple change.
2. We keep deferring to NR-NTN for multiple aspects: NR-NTN will support feedback disabled processes

If a simple enhancement like this, that mitigates against such significant losses, is not even looked at by the group, we fail to understand whether there is real intent by the group on having a reasonable working system in Rel 17! *If we are going to declare something simple that mitigates a 11x throughput/latency loss as “non-essential”, we fail to understand what the group deems essential!*We kindly request companies to give this a little bit of open-minded consideration. It isn’t something new, and it isn’t something that requires much work; however, the benefits are more than significant! |
| Ericsson | We support the FL opinion that HARQ feedback disabling should not be introduced in Rel-17. |
| Spreadtrum | We support the moderator’s conclusion of not introducing the disabling of HARQ feedback at this stage. |
| CATT | Considering limited time in R17 IoT NTN, no additional enhancement on HARQ disabling is needed.  |
| Xiaomi | Support FL’s conclusion on HARQ feedback disabling should not be introduced in Rel-17. |
| SONY2 | We support the FL opinion that HARQ feedback disabling should not be introduced in Rel-17.Enhancements can be considered in later releases. These enhancements can consider the amount of throughput / latency gain there is from this feature, but we think that it is less than 11 times. The meaning of “essential minimum functionality” has never been clear. At some stage, IoT-NTN should or at least attempt to meet the 5G / ITU mMTC requirements. IoT-NTN should also support higher value / higher data rate applications. |
| Hughes/EchoStar | We support moderator’s proposal of not introducing the disabling of HARQ feedback in Release 17 timeframe. |
| ESA | We support moderator’s proposal. |
| Inmarsat | We support the moderator’s proposal.  |

## Reduced PDCCH monitoring

This issue relates to the monitoring of a PDCCH which indicates the ACK/NACK after transmission of a PUSCH. Since the PDCCH would not be received before a RTT after the end of the transmission of the corresponding PUSCH, it is discussed whether the UE can skip monitoring PDCCH for a time interval that would be related to the RTT.

As background, this issue was discussed in past meetings, and in RAN1#104b-e the following proposals where discussed at length but then not agreed.

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| From RAN1#104b-e (email discussion and GTW)Updated Proposal 2-1 For NB-IoT and eMTC in NTN, further study ~~the following aspects~~ * ~~whether performance requirement for prioritized delay-tolerant small packet transmissions can be fulfilled without disabling HARQ feedback~~

the impact of disabling HARQ feedback on throughput, latency and power consumption. * + ~~FFS the study should not be limited to small packet transmissions~~

Proposal 4-1a: Further discuss in RAN1#105-e * Benefits and impact ~~or~~ an NTN UE configured with one HARQ process, when HARQ feedback is enabled the UE can be configured ~~does~~ not to monitor PDCCH until the RTT time has elapsed from the end of the PUSCH.

Proposal 4-2: Further discuss in RAN1#105-e * Benefits and impact for the monitoring of a PDCCH which indicates ACK/NACK feedback after transmission of a PUSCH when the number of configured HARQ processes is 2 (for NB-IoT in NTN) or larger than 1 (for eMTC in NTN).
 |

In this meeting companies provided further inputs that are summarized in Table 2.

Some companies [1, 2, 3, 4, 16] think that for a UE that is configured with one HARQ process, if the PUSCH transmission ends in a subframe n, the corresponding PDCCH which indicates an ACK/NACK would not be received before the RTT time has elapsed from the end of the PUSCH transmission. Thus, the UE can stop PDCCH monitoring to reduce power consumption since a new grant would not be received until after one RTT. It is observed in [8] that it is not possible for a UE not to monitor PDCCH because the UE might be scheduled to transmit new unicast data before one RTT has passed. In addition, the UE may need to monitor DCI for other scheduling assignments e.g. paging, system information, etc.

When a UE is configured with 2 HARQ processes, depending on the scheduling of the two PDCCH corresponding to the two PUSCH, a UE cannot stop monitoring of a PDCCH after transmission of a PUSCH as a PDCCH can be received before RTT has elapsed from the end of the PUSCH transmission. Some companies [1,2, 3,4,16] would agree to stop monitoring of PDCCH under certain conditions, while some other companies have concern that, even if no other DL reception is missed while not monitoring PDCCH, the potential power saving for skipping PDCCH monitoring may not materialize [6] or the consideration of additional PDCCH monitoring restrictions in RAN1 specs would be redundant and might interfere or override what is already defined by DRX in RAN2 [8].

**Table 2 Views on reduced PDCCH monitoring**

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| **Company** | **Inputs** |
| [1] [R1-2104261](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102346.zip)Huawei, HiSilicon  | **Observation** 1: For two DCIs followed by two PUSCHs scheduling, the gNB may sent DCI between the receptions of the two PUSCHs if the reception gap is large.**Proposal** 2: For two DCIs followed by two PUSCHs scheduling, define a threshold for the gap between PUSCHs. With gap less than the threshold, UE start monitoring NPDCCH after the RTT of the PUSCH from the first HARQ process. Otherwise, UE start monitoring NPDCCH after the RTT of the PUSCH from the second HARQ process. **Proposal** 3: With two HARQ processes, the transmission of NPDCCH should be enhanced, e. g. within a predefined time interval to reduce the NPDCCH monitoring.**Observation 2:** The earliest subframe for an UE to receive an NPDCCH with DCI format N0/N1 for the same HARQ process depends on the offset between the UL and DL frame timing at the eNB.**Proposal** 4: The PDCCH monitoring should take into consideration the timing offset between the UL and DL frame at the gNB. |
| [2] [R1-2104400](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102425.zip)Vivo | **Proposal** 5: When HARQ feedback is disabled, the PDCCH monitoring reduction is not necessary.**Observation** 2: When an IoT device is configured with two HARQ processes and the downlink and uplink frame timing are aligned at eNB, the IoT device is not expected to receive an NPDCCH with DCI format N0/N1 for the same HARQ process ID as the NPUSCH transmission until max(RTT time, 3 subframe) has elapsed from the end of the NPUSCH.**Observation** 3: When an IoT device is configured with two HARQ processes and the downlink and uplink frame timing are not aligned at eNB, the IoT device is not expected to receive an NPDCCH with DCI format N0/N1 for the same HARQ process ID as the NPUSCH transmission until max(RTT time, 3 subframe) has elapsed from the end of the NPUSCH.**Proposal** 6: When an IoT device is configured with two HARQ processes, the IoT device is not expected to receive an NPDCCH with DCI format N0/N1 for the same HARQ process ID as the NPUSCH transmission until max(RTT time, 3 subframe) has elapsed from the end of the NPUSCH.**Proposal** 7: When IoT device is configured with one HARQ process and the HARQ feedback is enabled, the IoT device does not require to monitor NPDCCH until max(RTT time, 3 subframe) has elapsed from the end of the NPUSCH. |
| [3] [R1-2104450](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102475.zip)Spreadtrum | **Proposal** 2: For an NTN UE configured with one HARQ process, when HARQ feedback is enabled, the UE does not monitor PDCCH until the RTT time has elapsed from the end of the PUSCH.**Proposal** 3: For the number of configured HARQ processes is 2 (for NB-IoT in NTN) or larger than 1 (for eMTC in NTN), if HARQ processes is full before the RTT time has elapsed from the end of the PUSCH, UE does not monitor PDCCH until the RTT time has elapsed from the end of the PUSCH. |
| [4] [R1-2104506](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102551.zip)CATT | **Proposal** 4: For an NTN UE configured with one HARQ process and for which HARQ feedback is enabled, the UE will not monitor PDCCH until the RTT time has elapsed from the end of the PUSCH.**Proposal** 5: For an NTN UE configured with two HARQ processes, and two processes are scheduled together, and for which HARQ feedback is enabled, the UE can skip PDCCH monitoring until RTT after the end of the reception of the last PDCCH.**Proposal** 6: For an NTN UE configured with two HARQ processes, there is no need for the enhancement on PDCCH monitoring. |
| [5] [R1-2104639](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102738.zip)CMCC | **Proposal** 2: If DL HARQ process and UL HARQ process are separately scheduled, and if simultaneous transmission of two HARQ processes, wherein one for PDSCH and one for PUSCH, is allowed, the benefit of reduced PDCCH monitoring (i.e., the UE to be configured not to monitor PDCCH until the RTT time has elapsed from the end of the PUSCH) on UE power saving needs further clarification.  |
| [8] [R1-2104817](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102834.zip)Ericsson | **Observation** 4 Latency should be analyzed for overall delay from application layer including delays introduced in different layers. The general effect of the RTT of the NTN network should be counted to estimate the overall delay of the eMTC for NTN.**Observation** 5 Similar to the latency, battery lifetime calculation requires more details to be considered than the effect of HARQ operation. Battery lifetime calculation requires more details to be considered than the effect of HARQ operation.**Proposal** 3 Following points need to be considered before introducing reduced PDCCH monitoring procedure: (1) Even if UE would not need to monitor PDCCH scheduling for unicast data, it is still required to perform PDCCH monitoring for other purposes including PDCCH monitoring receiving paging message, system information, etc. Therefore, UE cannot skip PDCCH monitoring only based on unicast data scheduling. (2) UE power saving procedure with respect to PDCCH monitoring is governed by the DRX functionality. Introducing any new procedure to deal with this issue should be aligned with or in relation to the DRX mechanism. Furthermore, DRX related functionality should be discussed mainly by RAN2. |
| [11] R1-2105185Sony | **Proposal** 1:Capture in the TR the benefits and drawbacks of not monitoring PDCCH when HARQ is stalled:* Benefit: The UE may save power by going to sleep
* Drawback: As for legacy DRX operation, the UE cannot be scheduled when sleeping
 |
| [12] [R1-2105196](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103063.zip)ZTE | **Proposal** 4: Reduced PDCCH monitoring can be achieved by enhancing UL HARQ RTT Timer in RAN2. |
| [15] [R1-2105553](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103269.zip)Xiaomi | **Proposal** 2: Study on reduced PDCCH monitoring is deprioritized in Rel-17 phase. |
| [16] R1-2105621Lenovo | **Proposal** 2: NB-IoT UE is to skip NPDCCH monitoring for an HARQ process for a longer time interval than the time interval in TN. |
| [17] R1-2105678InterDigital | **Proposal**-2: Reduced PDCCH monitoring with a single HARQ process is not studied further in RAN1. If necessary, RAN2 may study together with HARQ RTT enhancement for DRX operation. |
| [18] [R1-2105827](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103530.zip)APT,FGI,ITRI,III | [**Proposal** 2 For an NTN UE configured with one HARQ process, when HARQ feedback is enabled, the UE does not monitor PDCCH until the RTT time has elapsed from the end of the PUSCH.](file:///C%3A%5CUsers%5Ccarmela.c%5CAppData%5CLocal%5CTemp%5CTemp1_R1-2105827.zip%5CR1-2105827%20Enhancements%20on%20HARQ%20to%20NB-IoT%20in%20NTN.docx#_Toc71202650)[**Proposal** 3 PDCCH monitoring when a DRX cycle is configured shall be left to RAN2.](file:///C%3A%5CUsers%5Ccarmela.c%5CAppData%5CLocal%5CTemp%5CTemp1_R1-2105827.zip%5CR1-2105827%20Enhancements%20on%20HARQ%20to%20NB-IoT%20in%20NTN.docx#_Toc71202651) |

**Discussion\_1**

One discussion can be about the following considerations as opposite views have been expressed.

When a UE is configured with one HARQ process,

* the UE can stop PDCCH monitoring since a new grant would not be received until after one RTT
* the UE cannot stop PDCCH monitoring because the UE might be scheduled to transmit new unicast data before one RTT has passed and/or the UE may need to monitor DCI for other scheduling assignments e.g. paging, system information, etc.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE | The 2nd sub-bullet is preferred.  |
| Lenovo, MotoM | The first sub-bullet is preferred. Power saving is the most important factor to be considered for IoT. Consider the IoT delay tolerant feature, we can receive the new data and even paging/system information in next available PDCCH occasion. For an unexpected paging, system update, it doesn’t make sense to force UE to monitor PDCCH in the whole period without any available HARQ process number. As the NTN throughput is lower than TN throughput, the PDCCH occasion should be reduced accordingly in a particular period. We can either update PDCCH search space parameter (e.g., G) or stop monitoring PDCCH in a duration. The later one can give UE a long period of “sleep”. |
| vivo | According to TS 38.321 Section 5.7,“The MAC entity may be configured by RRC with a DRX functionality that controls the UE's PDCCH monitoring activity for the MAC entity's C-RNTI, CI-RNTI, CS-RNTI, INT-RNTI, SFI-RNTI, SP-CSI-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI, TPC-SRS-RNTI, and AI-RNTI.”We can find that DRX operation cannot control the UE’s PDCCH monitoring activity for paging and SI. That is, UE may need to monitor DCI for other scheduling assignments e.g. paging, system information. In our understanding, the UE monitoring behavior we discussed here should not result in large specification impact, and should be independent from the DRX operation. And if it has to be associated with the DRX operation, we should leave it to discuss in RAN2.  |
| CMCC | The 2nd sub-bullet is preferred.In our view, if DL HARQ process and UL HARQ process are separately scheduled, and if simultaneous transmission of two HARQ processes, wherein one for PDSCH and one for PUSCH, is allowed, the benefit of reduced PDCCH monitoring on UE power saving needs further clarification. In this case, in the interval between a transmission of PUSCH with one HARQ process and the corresponding UL grant (e.g., DCI Format N0 for NB-IoT), UE needs to continuously monitor UE specific search space for potential DL grant (DCI Format N1 in NB-IoT). Note that in either NB-IoT or eMTC, the UL grant and DL grant have the same DCI format size, with 1 bit to distinguish the DCI format (e.g., Flag for format N0/format N1 differentiation). Thus, only reduce the monitor occasions for UL grant will not reduce the UE power consumption, since UE still need to monitor DL grant which has the same scrambled RNTI and the same DCI format size as the UL grant. |
| Huawei, HiSilicon | We have concern on the UE power consumption if it is expected to continue monitoring PDCCH when PUSCH transmission has ended and before the ACK/NACK is due after one RTT. |
| MediaTek | First bullet seems preferable for power consumption. |
| Novamint | We do agree with Lenovo. First sub-bullet seems preferable |
| Nokia, NSB | As we point out in RAN1 #104b meeting, the PDCCH is not only used for unicast of PUSCH or PDSCH. It should not be allowed to fully stop UE monitoring PDCCH especially for e.g. scheduling of system information or other non-unicast scheduling purposes. |
| Qualcomm | This should be discussed in RAN2. Either way, we don’t have to make a binary decision in this meeting on this in RAN1. In general, we don’t see a reason to change existing behavior for PDCCH monitoring. It appears to us (please correct, if we are mistaken), that the proponents of the reduced monitoring want to disable monitoring for “other kinds of PDCCH”—otherwise, it seems that the definition of the HARQ RTT timer already ensures that the PDCCH for the HARQ process in question isn’t monitored before the timer expires. Why we should suddenly disable “other” PDCCH monitoring in NTN, while we don’t in TN (if this is indeed the intention), is not clear to us. |
| Ericsson | The 2nd sub-bullet is preferred.The following points need to be considered before introducing reduced PDCCH monitoring procedure: (1) Even if UE would not need to monitor PDCCH scheduling for unicast UL data, it is still required to perform PDCCH monitoring for other purposes including PDCCH monitoring receiving paging message, system information, PDSCH scheduling, etc. Therefore, UE cannot skip PDCCH monitoring only based on unicast data scheduling.(2) UE power saving procedure with respect to PDCCH monitoring is governed by the DRX functionality. Introducing any new procedure to deal with this issue should be aligned with or in relation to the DRX mechanism. Furthermore, DRX related functionality should be discussed mainly by RAN2. |
| CATT | In general, the first option is acceptable. For system information or Paging, we wonder if it belongs to same HARQ scope? |
| Xiaomi | We prefer the second sub-bullet |
| SONY2 | Our preference is the first bullet, but we are OK to capture both views in the TR.Our view on the second bullet is that it is quite clear that if the UE does not monitor PDCCH then it cannot be scheduled. This is what happens in any DRX functionality. Why is it such a problem that the UE cannot be scheduled with PDSCH when the UE is implementing some DRX functionality? |
| Hughes/EchoStar | We prefer first bullet for power consumption. |
| Inmarsat | Power consumption should be the highest priority, but we are open to capture both in the TR. |

**Discussion\_2**

Any further consideration on the amount of UE power saving in case it is allowed to stop PDCCH monitoring after a PUSCH transmission (for a period of time related to RTT).

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE | The PDCCH monitoring related can be up to the settings of DRX timer in RAN2. |
| Lenovo, MotoM | Support the study. |
| vivo | Support the study. |
| OPPO | Support the study. |
| Huawei, HiSilicon | Additional periods of keeping the UE baseband circuitry and radio front end active accumulate over service periods aiming at several years in the field. Ideally, the UE would be able to go to sleep in between completing PUSCH transmission and the expected time of ACK/NACK receipt. |
| MediaTek | The amount of power saving would be more significant for GEO. It may be left to UE implementation to go to micro sleep in connected DRX after a PUSCH transmission. |
| Qualcomm | Not sure about the exact proposal here; in general, the motivation for NTN-specific changes vis-à-vis TN (if that is the intent) isn’t apparent to us at this point.As has been described before, due to the GNSS reads required, the power consumption from everything else is relatively much smaller in NTN-IoT, which makes NTN-specific changes to PDCCH monitoring (over existing behavior in TN) even less impactful. |
| Ericsson | Discussion 1 should be concluded first. The amount of power saving depends on DRX behavior and timer settings determined by RAN2. |
| CATT | NO need further study.  |
| SONY2 | Support the study. The power saving will be greater for GEO. |
| Inmarsat | We tend to agree with MediaTek’s comment that micro sleep cycles in DRX could be up to UE implementation, but a baseline behavior should be established that allows the UE to save power. |

## Other HARQ feedback mechanisms

**Table 3 Views on introducing additional HARQ feedback**

|  |  |
| --- | --- |
| **Company** | **Inputs** |
| [R1-2105348](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103073.zip)Samsung | **Proposal** 4: UE assistance information for HARQ can be supported. |
| [R1-2105407](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103135.zip)Nokia | **Observation** 2: The UE may be able to provide early termination indication to the network to indicate when sufficient number of repetitions are received. **Proposal** 1: If HARQ feedback disabling is supported, alternative long-term feedback for HARQ, e.g. assistance on requested number of repetition, BLER-based triggering or bundling of feedback, should be considered to maximize the performance of the link. |

Proposals are about reporting additional information by a UE which would be useful especially if HARQ feedback disabling is supported. The following types of reporting have been considered:

* Timing – UE informs the network a sufficient number of repetitions has been transmitted
* UE assistance on requested number of repetition, BLER-based triggering or bundling of feedback, should be considered to maximize the performance of the link
* Buffer status
* Request for HARQ disabling/enabling

Similar to RAN1#104b-e, only 2 companies proposed to introduce additional feedback. This topic is also related to disabling HARQ feedback discussed in Sec.2.1. Given the low interest in this issue, a discussion about recommending any of the proposed solutions seems not feasible. However, any further inputs can be provided in the table below.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE | No need to introduce additional feedback mechanism |
| Lenovo, MotoM | No need to introduce additional feedback mechanism |
| vivo | Not essential in this release, further discussion in further release. |
| CMCC | No need to introduce additional feedback mechanism |
| OPPO | No need to introduce additional feedback mechanism |
| Huawei, HiSilicon | We agree with the moderator’s conclusion |
| MediaTek | We agree with moderator’s conclusions |
| Apple | Agree with FL’s recommendation, no further enhancement is considered.  |
| Novamint | Agree with the moderator’s conclusion. |
| Nokia, NSB | If HARQ feedback disabling is supported, as we proposed, the long-term feedback with less overhead and no additional latency for data transmission will help for link adaptation and throughput enhancement.If HARQ feedback disabling is not supported in Rel 17 IoT NTN, then we agree not introduce additional feedback if no special benefit. |
| Ericsson | No need to introduce additional feedback mechanism |
| Spreadtrum | No need to introduce additional feedback mechanism |
| CATT | No need additional mechanism. |
| Xiaomi | No need to have additional mechanism. |
| SONY2 | No need for additional mechanisms |
| Hughes/EchoStar | OK with moderator’s proposal |
| Inmarsat | Agree with moderator’s proposal for Release 17. Optimizations are good to capture for future post-Rel 17 work.  |

## Serving cell change

**Table 4 Views on enhancements for serving cell change**

|  |  |
| --- | --- |
| **Company** | **Inputs** |
| [R1-2104400](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102425.zip)Vivo | **Proposal** 3: Beam management mechanism can be introduced to IoT NTN.**Proposal** 4: An enhanced gap transmission mechanism to allow repetition continuation when serving beam switches could be considered. |
| R1-2105185Sony | **Proposal** 2: Capture the following in the TR:RAN1 discussed the feasibility of the following schemes to guarantee performance when a UE changes cell or beam:* combining repetitions over two cells/beams
* deferring transmissions (such that the transmission does not start as a beam is going to go out of view)
* not flushing HARQ buffers at cell change (such that a retransmission can be performed in the next cell, rather than repeating transmissions between cells)

Due to the large number of repetitions, an UL/DL transmission in IoT can be longer than the time interval needed by the UE for cell reselection or handover or beam switching.  |
| [R1-2105407](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103135.zip)Nokia | **Proposal** 2: Solution of repetition continuation for HARQ process and combination of repetition from coverage of two cells, especially for LEO with high speed satellite movement, should be added as candidate solution in TR 36.763. With the detail evaluation/discussion on the candidate solution to be discussed in normative phase. |

Due to the large number of repetitions, an UL/DL transmission in IoT can be longer than the time interval needed by the UE for cell reselection or handover. This can be an issue especially for LEO satellite due to high mobility. It is possible that some repetitions can’t be transmitted before the cell change happens and this will cause a waste of resources. It is proposed to study the feasibility of combining repetitions from the two cells and also combining repetitions from different beams. Companies propose to list the solutions to address this issue in the TR.

Three companies proposed to address this issue and capture potential solutions in the TR. These proposals were already discussed in previous meetings. Given the low interest in this issue, a discussion about recommending any of the proposed solutions seems not feasible. However, any further inputs can be provided in the table below.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE | For this issue (e.g., some repetitions cannot be transmitted before the cell or beam change happens and this will cause a waste of resources), we need think further on whether such behavior will be allowed or not from scheduling perspective. According to analysis, the degradation of serving quality for each beam/cell may not be dramatic since in current assumption the valid range is defined by 3dB beamwidth. In this case, the UE can still complete the transmission before cell/beam changes. |
| Lenovo, MotoM | We agree to address the issue and potential solutions in TR. It is a common case that serving satellite moves out of the coverage in the long period of uplink transmission. |
| vivo | As discussed in our contributions, for the scenarios of Set 1 and Set 2, assuming one beam per cell is used, the maximum service time provided by one cell for IoT device is 6.612s (set 1) or 11.901s (set 2), it is very likely that the repetition transmission may be ongoing when the serving cell needs to change due to the mobility of satellites, this is an issue may cause unavailable service for some UEs need large repetition factor and a waste of resource. We propose to at least address this issue into the TR and further discuss potential solutions in WI, such as repetition continuation and combine when serving beam / cell change.  |
| CMCC | Regarding serving cell change issue, the feasibility on implementation-based solutions, such as scheduling optimization, can be studied with high priority.Combining repetitions from the two cells/beams is not preferred. |
| OPPO | We think this issue can be addressed in TR if it is common understanding and the potential solutions can be discussed in the WI. |
| Huawei, HiSilicon | As this requires RAN2 involvement we cannot see how a feasible conclusion can be reached in the very limited time available.  |
| Apple | Agree with FL’s recommendation, no further enhancement is considered.  |
| Novamint | Unlikely to reach a conclusion in the limited time available as dependencies to RAN2. |
| Nokia, NSB | This is a special issue for IoT NTN comparing with NR NTN.As mentioned by moderator, the long time repetition for IoT UE may be longer than the remaining serving time by the cell before cell reselection or handover, then it will result the transmission stopping when cell reselection/handover needed, with resource waste or even the data can never be transmitted successfully.To make the system work, this issue should be studied and captured in TR 36.763, where solution(s) should be added in Rel 17.While as LTE IoT UE do not support beam related processing, we do not think it is needed to add combination for repetitions for two beams. |
| Ericsson | It is not feasible to solve this issue within the limited time left. |
| Spreadtrum | Taking into account the time limit of R17, combining repetitions from the two cells/beams can be considered in R18. |
| CATT | It is related to RAN2 scope.  |
| SONY2 | We should at least capture in the TR that there is an issue here. Many companies in this table have commented that there is a problem to be solved here. It may be difficult to converge on a solution in the time left this week. |
| Inmarsat | This can be captured in the TR, but should be outside of Rel 17 scope. |

## Throughput enhancements

**Table 5 Views on throughput enhancements**

|  |  |
| --- | --- |
| **Company** | **Input** |
| [R1-2104825](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102908.zip)Qualcomm | **Observation** 2: For GEO Set 1 deployments, with cell-specific K\_offset, the waiting period between receiving a NPDSCH and transmitting the HARQ-ACK (which is given by the maximum differential delay in the cell) can accommodate at least one PDCCH, provided it coincides with a valid PDCCH monitoring occasion.**Proposal** 2: RAN1 to consider enabling PDCCH monitoring in “waiting periods”—for example, between receiving NPDSCH and transmitting HARQ ACK in NB-IoT—to mitigate suboptimal throughput. |

One company proposes to enable PDCCH monitoring during the time period between receiving NPDSCH and transmitting HARQ ACK in NB-IoT to mitigate suboptimal throughput. This proposal was already discussed in previous meetings. Given the low interest in this issue, a discussion about recommending the proposed solution seems not feasible. However, any further inputs can be provided in the table below.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE | For addressing the needs on throughput enhancement, it can be easily handled by disabling the HARQ feedback as discussed in section 2.1. |
| Lenovo, MotoM | Although, throughput is not an essential target for IoT NTN, especially for Rel.17, We agree to study the potential solution if possible. |
| vivo | Not essential in this release, further discussion in further release. |
| CMCC | Not essential in this release, further discussion in further release.In our view, the mentioned “waiting periods” is about the differential TA between a given UE and the farthest UE in the beam edge. Compared with the RTD between a UE and a satellite, the differential TA within a beam seems trivial. Thus, the potential enhancement on PDCCH monitoring in current “waiting periods” between receiving NPDSCH and transmitting HARQ ACK in NB-IoT to enhance throughput for NB-IoT in NTN is non-essential. |
| OPPO | Not essential in this release. |
| Huawei, HiSilicon | We agree with the moderator’s observation that further discussion on this solution is not feasible at this stage. |
| Apple | Agree with FL’s recommendation, no further enhancement is considered.  |
| Novamint | Not essential for this release. No further enhancement to be considered at this stage. |
| Nokia, NSB | We think no need to discuss this before any issue found that the target data rate can not be achieved. |
| Qualcomm | While we have demonstrated that it is possible to utilize the waiting periods for certain scenarios (GEO with cell-specific K\_offset), in the interest of progress, we are OK if this is not considered for Rel 17. We still believe however, that the issue identified, and the solution proposed should be captured in the TR, for potential discussion in future releases. |
| Ericsson | Not essential in this release. |
| Spreadtrum | We agree with the moderator’s recommendation. Further discussion can be considered in R18. |
| CATT | No need |
| SONY2 | We can consider throughput enhancements in a later release |
| Hughes/EchoStar | Enhancement in later release |
| Inmarsat | Can be considered after Rel 17 |

# Companies’ proposals and observations

|  |  |
| --- | --- |
| **Company** | **Inputs** |
| [R1-2104261](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102346.zip)Huawei,HiSilicon  | **Observation** 1: For two DCIs followed by two PUSCHs scheduling, the gNB may sent DCI between the receptions of the two PUSCHs if the reception gap is large.**Observation** 2: The earliest subframe for an UE to receive an NPDCCH with DCI format N0/N1 for the same HARQ process depends on the offset between the UL and DL frame timing at the eNB.**Proposal** 1: Disabling HARQ processes is not necessary for IoT-NTN.**Proposal** 2: For two DCIs followed by two PUSCHs scheduling, define a threshold for the gap between PUSCHs. With gap less than the threshold, UE start monitoring NPDCCH after the RTT of the PUSCH from the first HARQ process. Otherwise, UE start monitoring NPDCCH after the RTT of the PUSCH from the second HARQ process. **Proposal** 3: With two HARQ processes, the transmission of NPDCCH should be enhanced, e. g. within a predefined time interval to reduce the NPDCCH monitoring.**Proposal** 4: The PDCCH monitoring should take into consideration the timing offset between the UL and DL frame at the gNB. |
| [R1-2104400](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102425.zip)Vivo | **Observation** 1: It can be up to network implementation to configure the enabling/disabling HARQ feedback for one HARQ process, and determine the number of disabled HARQ processes.**Observation** 2: When an IoT device is configured with two HARQ processes and the downlink and uplink frame timing are aligned at eNB, the IoT device is not expected to receive an NPDCCH with DCI format N0/N1 for the same HARQ process ID as the NPUSCH transmission until max(RTT time, 3 subframe) has elapsed from the end of the NPUSCH.**Observation** 3: When an IoT device is configured with two HARQ processes and the downlink and uplink frame timing are not aligned at eNB, the IoT device is not expected to receive an NPDCCH with DCI format N0/N1 for the same HARQ process ID as the NPUSCH transmission until max(RTT time, 3 subframe) has elapsed from the end of the NPUSCH.**Proposal** 1: Support the functionality of disabling HARQ feedback for NB-IoT/eMTC over NTN.**Proposal** 2: The functionality of enabling/disabling HARQ feedback per HARQ process can be semi-statically configured and dynamically switched.**Proposal** 3: Beam management mechanism can be introduced to IoT NTN.**Proposal** 4: An enhanced gap transmission mechanism to allow repetition continuation when serving beam switches could be considered.**Proposal** 5: When HARQ feedback is disabled, the PDCCH monitoring reduction is not necessary.**Proposal** 6: When an IoT device is configured with two HARQ processes, the IoT device is not expected to receive an NPDCCH with DCI format N0/N1 for the same HARQ process ID as the NPUSCH transmission until max(RTT time, 3 subframe) has elapsed from the end of the NPUSCH.**Proposal** 7: When IoT device is configured with one HARQ process and the HARQ feedback is enabled, the IoT device does not require to monitor NPDCCH until max(RTT time, 3 subframe) has elapsed from the end of the NPUSCH. |
| [R1-2104450](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102475.zip)Spreadtrum | **Proposal** 1: Whether to support disabling HARQ feedback for IOT NTN can be considered in R18.**Proposal** 2: For an NTN UE configured with one HARQ process, when HARQ feedback is enabled, the UE does not monitor PDCCH until the RTT time has elapsed from the end of the PUSCH.**Proposal** 3:For the number of configured HARQ processes is 2 (for NB-IoT in NTN) or larger than 1 (for eMTC in NTN), if HARQ processes is full before the RTT time has elapsed from the end of the PUSCH, UE does not monitor PDCCH until the RTT time has elapsed from the end of the PUSCH. |
| [R1-2104506](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102551.zip)CATT | **Observation** 1: Disabling HARQ feedback doesn’t show clear benefit to NB-IoT NTN and CEmodeA eMTC use case.**Proposal** 1: Reuse disabling HARQ feedback mechansim of NR NTN for CEmodeB in eMTC NTN.**Proposal** 2: No enhancement in disabling HARQ feedback is needed for HARQ in NB-IoT NTN and CEmodeA eMTC over satellite. **Proposal** 3: Enabling/disabling on HARQ feedback for downlink transmission should be at least configurable per HARQ process via UE specific RRC signalling.**Proposal** 4: For an NTN UE configured with one HARQ process and for which HARQ feedback is enabled, the UE will not monitor PDCCH until the RTT time has elapsed from the end of the PUSCH.**Proposal** 5: For an NTN UE configured with two HARQ processes, and two processes are scheduled together, and for which HARQ feedback is enabled, the UE can skip PDCCH monitoring until RTT after the end of the reception of the last PDCCH.**Proposal** 6: For an NTN UE configured with two HARQ processes, there is no need for the enhancement on PDCCH monitoring. |
| [R1-2104570](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102620.zip)MTK | **Observation** 1: for NB-IoT, HARQ stalling reduces data rates by approximately 95% and 49% for GEO and LEO respectively. **Observation** 2: for NB-IoT, HARQ can be used without disabling HARQ feedback with data rates consistent with sporadic short transmissions.**Observation** 3: for NB-IoT, the maximum latency with 2 HARQ processes with up to 4 HARQ transmissions is 2264 ms. **Observation** 4: for NB-IoT, HARQ can be used without disabling HARQ feedback with latency consistent with sporadic short transmissions.**Proposal** 1: HARQ feedback is not disabled in connected.**Proposal** 2: UL HARQ feedback is not disabled for Message 3 during initial access. |
| [R1-2104639](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102738.zip)CMCC | **Observation** 1: Disabling HARQ feedback is beneficial to throughput improvement and latency reduction.**Observation** 2: If reliable transmission is required, disabling HARQ feedback may increase the power consumption.* If HARQ feedback is disabled, higher repetition number may be configured, which may significantly increase the power consumption for DL data reception.
* If retransmission at RLC layer (i.e. RLC ARQ) is supported, UE may need to awake for a longer time to wait for the potential retransmission scheduling signaling trigged by RLC layer, which may increase the power consumption for PDCCH monitoring.

**Proposal** 1: The impact of disabling HARQ feedback on power consumption, as well as whether reliability reduction is acceptable in IoT NTN, needs further study.**Proposal** 2: If DL HARQ process and UL HARQ process are separately scheduled, and if simultaneous transmission of two HARQ processes, wherein one for PDSCH and one for PUSCH, is allowed, the benefit of reduced PDCCH monitoring (i.e., the UE to be configured not to monitor PDCCH until the RTT time has elapsed from the end of the PUSCH) on UE power saving needs further clarification.**Proposal** 3: Enhancement on PDCCH monitoring in current “waiting periods” between receiving NPDSCH and transmitting HARQ ACK in NB-IoT to enhance throughput for NB-IoT in NTN is non-essential. |
| [R1-2104780](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102757.zip)OPPO | **Proposal** 1: HARQ disabling for NB-IoT/eMTC over NTN should NOT be specified in Rel-17. **Proposal** 2: HARQ disabling and increased HARQ process number for NB-IoT/eMTC over NTN should be studied and specified in later release.  |
| [R1-2104817](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102834.zip)Ericsson | **Observation** 1 The current specification does not require the gNB to wait for reception of HARQ-ACK for a DL HARQ process before scheduling a new TB for that HARQ process. gNB can maintain downlink peak data rate by scheduling new TB for a given DL HARQ process immediately after the UE transmits the HARQ-ACK feedback.**Observation** 2 The current specification does not require the gNB to wait for reception of a TB for an UL HARQ process before scheduling a new TB for that HARQ process. The gNB can maintain uplink peak data rate by scheduling new TB for a given UL HARQ process immediately after the UE transmits the previous PUSCH.**Observation** 3 When gNB schedules a new TB for a HARQ process without waiting for HARQ-ACK feedback reception of the same HARQ process, the HARQ-ACK feedback can still be beneficial for other purposes including outer-loop link adaption.**Observation** 4 Latency should be analyzed for overall delay from application layer including delays introduced in different layers. The general effect of the RTT of the NTN network should be counted to estimate the overall delay of the eMTC for NTN.**Observation** 5 Similar to the latency, battery lifetime calculation requires more details to be considered than the effect of HARQ operation. Battery lifetime calculation requires more details to be considered than the effect of HARQ operation.**Proposal** 1 RAN1 to conclude that, according to current specification, gNB can maintain downlink peak data rate by scheduling new TB for a given HARQ process without waiting for reception of the HARQ-ACK feedback of that HARQ process.**Proposal** 2 RAN1 to conclude that, according to current specification, gNB can maintain uplink peak data rate by scheduling new UL TB for a given HARQ process without waiting for reception of the previous TB of that HARQ process.**Proposal** 3 Following points need to be considered before introducing reduced PDCCH monitoring procedure: (1) Even if UE would not need to monitor PDCCH scheduling for unicast data, it is still required to perform PDCCH monitoring for other purposes including PDCCH monitoring receiving paging message, system information, etc. Therefore, UE cannot skip PDCCH monitoring only based on unicast data scheduling. (2) UE power saving procedure with respect to PDCCH monitoring is governed by the DRX functionality. Introducing any new procedure to deal with this issue should be aligned with or in relation to the DRX mechanism. Furthermore, DRX related functionality should be discussed mainly by RAN2. |
| [R1-2104825](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102908.zip)Qualcomm | **Observation** 1: For GEO Set 1 deployments, not supporting any feedback disabled HARQ process(es) results in a throughput/latency penalty of > 11x for UEs with one HARQ process and > 5.5x for UEs with two HARQ processes.**Proposal** 1: RAN1 to support at least one feedback-disabled HARQ process for NB-IoT over NTN. FFS eMTC.**Observation** 2: For GEO Set 1 deployments, with cell-specific K\_offset, the waiting period between receiving a NPDSCH and transmitting the HARQ-ACK (which is given by the maximum differential delay in the cell) can accommodate at least one PDCCH, provided it coincides with a valid PDCCH monitoring occasion.**Proposal** 2: RAN1 to consider enabling PDCCH monitoring in “waiting periods”—for example, between receiving NPDSCH and transmitting HARQ ACK in NB-IoT—to mitigate suboptimal throughput. |
| [R1-2105141](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2102919.zip)Apple | **Observation** 1: Disabling HARQ feedback for downlink transmissions may increase throughput, at the cost of reduced reliability and increased latency. **Observation** 2: Disabling HARQ feedback for downlink transmissions does not increase the IoT device complexity and can reduce the power consumption. **Proposal** 1: Disabling HARQ feedback for downlink transmissions is supported for IoT over NTN. **Proposal** 2: Disabling HARQ feedback for downlink transmission is configurable per HARQ process via UE specific RRC signaling.  |
| R1-2105185Sony | **Proposal** 1:Capture in the TR the benefits and drawbacks of not monitoring PDCCH when HARQ is stalled:* Benefit: The UE may save power by going to sleep
* Drawback: As for legacy DRX operation, the UE cannot be scheduled when sleeping

**Proposal** 2: Capture the following in the TR:RAN1 discussed the feasibility of the following schemes to guarantee performance when a UE changes cell or beam:* combining repetitions over two cells/beams
* deferring transmissions (such that the transmission does not start as a beam is going to go out of view)
* not flushing HARQ buffers at cell change (such that a retransmission can be performed in the next cell, rather than repeating transmissions between cells)

Due to the large number of repetitions, an UL/DL transmission in IoT can be longer than the time interval needed by the UE for cell reselection or handover or beam switching.  |
| [R1-2105196](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103063.zip)ZTE | **Proposal** 1: HARQ feedback disabling for DL only should be supported in IoT-NTN.**Proposal** 2: Dynamic configuration of HARQ feedback disabling should be supported in IoT-NTN.**Proposal** 3: Enhancement on UL HARQ to increase throughput is not needed in IoT-NTN.**Proposal** 4: Reduced PDCCH monitoring can be achieved by enhancing UL HARQ RTT Timer in RAN2. |
| [R1-2105348](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103073.zip)Samsung | **Proposal** 1: Disabling of HARQ feedback should be supported as NR NTN.**Proposal** 2: HARQ feedback can be enabled/disabled per HARQ process via UE specific RRC signaling as NR NTN.**Proposal** 3: Whether to support disabling of HARQ feedback for all the HARQ processes should be discussed.**Proposal** 4: UE assistance information for HARQ can be supported. |
| [R1-2105407](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103135.zip)Nokia | **Observation** 1: repetition for IoT UE will mitigate the impact of HARQ stalling because of long propagation delay in NTN scenario.**Observation** 2: The UE may be able to provide early termination indication to the network to indicate when sufficient number of repetitions are received. **Observation** 3: HARQ feedback disabling is impacting link adaptation in some IoT NTN scenarios. **Proposal** 1: If HARQ feedback disabling is supported, alternative long-term feedback for HARQ, e.g. assistance on requested number of repetition, BLER-based triggering or bundling of feedback, should be considered to maximize the performance of the link.**Proposal** 2: Solution of repetition continuation for HARQ process and combination of repetition from coverage of two cells, especially for LEO with high speed satellite movement, should be added as candidate solition in TR 36.763. With the detail evaluation/discussion on the candidate solution to be discussed in normative phase. |
| [R1-2105553](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103269.zip)Xiaomi | **Proposal** 1: HARQ disabling is not supported for IoT NTN.**Proposal** 2: Study on reduced PDCCH monitoring is deprioritized in Rel-17 phase. |
| R1-2105621Lenovo | **Proposal** 1: At least for NBIoT NTN, disabling HARQ is not supported, and for eMTC, especially CE mode A, disabling HARQ can be considered in Rel.18 due to limited time for this release.**Proposal** 2: NB-IoT UE is to skip NPDCCH monitoring for an HARQ process for a longer time interval than the time interval in TN. |
| R1-2105678InterDigital | **Proposal**-1: Disabling HARQ feedback is not supported in Rel-17 in IoT NTN**Proposal**-2: Reduced PDCCH monitoring with a single HARQ process is not studied further in RAN1. If necessary, RAN2 may study together with HARQ RTT enhancement for DRX operation. |
| [R1-2105827](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104b%5CDocs%5CR1-2103530.zip)APT,FGI,ITRI,III | [**Observation** 1 RAN2 has agreed that enable and disable HARQ feedback is R2 scope.](file:///C%3A%5CUsers%5Ccarmela.c%5CAppData%5CLocal%5CTemp%5CTemp1_R1-2105827.zip%5CR1-2105827%20Enhancements%20on%20HARQ%20to%20NB-IoT%20in%20NTN.docx#_Toc71202647)[**Observation** 2 In this release, the MAC entity can disable HARQ feedback by not indicating to the PHY layer.](file:///C%3A%5CUsers%5Ccarmela.c%5CAppData%5CLocal%5CTemp%5CTemp1_R1-2105827.zip%5CR1-2105827%20Enhancements%20on%20HARQ%20to%20NB-IoT%20in%20NTN.docx#_Toc71202648)[**Proposal** 1 Disabling HARQ feedback for NB-IoT over NTN is recommended not to be discussed in RAN1.](file:///C%3A%5CUsers%5Ccarmela.c%5CAppData%5CLocal%5CTemp%5CTemp1_R1-2105827.zip%5CR1-2105827%20Enhancements%20on%20HARQ%20to%20NB-IoT%20in%20NTN.docx#_Toc71202649)[**Proposal** 2 For an NTN UE configured with one HARQ process, when HARQ feedback is enabled, the UE does not monitor PDCCH until the RTT time has elapsed from the end of the PUSCH.](file:///C%3A%5CUsers%5Ccarmela.c%5CAppData%5CLocal%5CTemp%5CTemp1_R1-2105827.zip%5CR1-2105827%20Enhancements%20on%20HARQ%20to%20NB-IoT%20in%20NTN.docx#_Toc71202650)[**Proposal** 3 PDCCH monitoring when a DRX cycle is configured shall be left to RAN2.](file:///C%3A%5CUsers%5Ccarmela.c%5CAppData%5CLocal%5CTemp%5CTemp1_R1-2105827.zip%5CR1-2105827%20Enhancements%20on%20HARQ%20to%20NB-IoT%20in%20NTN.docx#_Toc71202651) |

# References

1. R1-2104261 Discussion on HARQ enhancement for IoT in NTN Huawei, HiSilicon
2. R1-2104400 Discussion on HARQ enhancements on NB-IoT\_eMTC for NTN vivo
3. R1-2104450 Consideration on enhancements on HARQ for IoT NTN Spreadtrum Communications
4. R1-2104506 HARQ operation enhancement for NB-IoT/eMTC CATT
5. R1-2104570 Enhancements on HARQ for IoT NTN MediaTek Inc.
6. R1-2104639 Enhancements on HARQ for IoT NTN CMCC
7. R1-2104780 Discussion on HARQ enhancements OPPO
8. R1-2104817 On HARQ enhancements for IoT NTN Ericsson
9. R1-2104825 Enhancements on HARQ Qualcomm Incorporated
10. R1-2105141 HARQ Enhancement in IoT NTN Apple
11. R1-2105185 HARQ enhancements for IoT-NTN Sony
12. R1-2105196 Discussion on HARQ for IoT-NTN ZTE
13. R1-2105348 On enhancements on HARQ Samsung
14. R1-2105407 HARQ for NB-IoT/eMTC over NTN Nokia, Nokia Shanghai Bell
15. R1-2105553 Discussion on the HARQ enhancement for IoT NTN Xiaomi
16. R1-2105621 HARQ enhancement for IoT NTN Lenovo, Motorola Mobility
17. R1-2105678 HARQ enhancement for IoT NTN InterDigital, Inc.
18. R1-2105827 Enhancements on HARQ to NB-IoT in NTN Asia Pacific Telecom, FGI

# Annex A – Agreements 8.15.4 Enhancements on HARQ in NTN-IoT

**RAN1#104-e**

Agreement:

Study further the potential benefits and/or drawbacks of increasing the number of HARQ processes on throughput, latency, power consumption and complexity

Agreement:

* For NTN, further study potential benefits and/or drawbacks of disabling HARQ feedback for NB-IoT.
* For NTN, further study potential benefits and/or drawbacks of disabling HARQ feedback for eMTC.

Agreement:

In relation to HARQ operation in NTN IoT, further study at least

* The necessity, potential benefits and drawbacks of any other potential HARQ feedback mechanisms
* The necessity, potential benefits and drawbacks of reduced PDCCH monitoring
* The necessity, potential benefits and drawbacks of coverage enhancements
* The necessity, potential benefits and drawbacks of uplink transmission gaps with multiple HARQ processes
* The necessity, potential benefits and drawbacks of maintaining HARQ process continuity in serving cell change
* The necessity, potential benefits and drawbacks of multiple Transport Blocks scheduling
* The necessity, potential benefits and drawbacks of throughput enhancements
	+ FFS: Whether target throughput in NTN will be the same as target throughput in terrestrial networks

Agreement:

The motivation for introducing HARQ enhancements in NR NTN needs further consideration for HARQ enhancements in NTN IoT. Capture the following in the TR:

* For NTN IoT, potential HARQ enhancements need to consider the main characteristics of an IoT device, which are low complexity, low cost, low power consumption and low throughput, and key requirements of IoT services which are extended coverage, delay-tolerant and infrequent data transmissions, and support of massive communications.
* The peak throughput of IoT UEs operating over NTN is not expected to be higher than the peak throughput of IoT UEs operating over TN.

Agreement:

Further study to identify whether HARQ stalling happens at least in the GEO satellite scenario.

Agreement:

* Further discuss the potential benefits and/or drawbacks of increasing the number of HARQ processes in the UL for NB-IoT and eMTC, and for the analysis consider at least the following for the number of HARQ processes
	+ NB-IoT: 1,2,4
	+ eMTC: 2,4,8,14
* And discuss at least power consumption and peak data rate as performance metrics
* FFS: Whether to consider DL
* Other values for number of HARQ processes below the maximum value can be discussed

Agreement:

* Further discuss the potential benefits and/or drawbacks of disabling HARQ feedback for NB-IoT and eMTC, and consider at least the following number of HARQ processes for the analysis
	+ NB-IoT:
		- Total: 2, disabled: {1,2}
	+ eMTC:
		- Total: 2, disabled: {1,2}
		- Total: 8, disabled: {1,2,7,8}
* Other values for number of HARQ processes below the maximum value can be discussed
* FFS: whether to consider separately LEO and GEO scenarios
* FFS: whether to allow disabling of HARQ feedback in case of single HARQ process
* FFS: whether to allow disabling of all HARQ feedback
* FFS: other details for the evaluation/analysis.

**RAN1#104b-e**

Agreement:

Increasing the number of HARQ processes for NB-IoT and for eMTC in NTN is recommended not to be supported in Rel-17.

# Annex B – Agreements 8.4.3 Enhancements on HARQ in NTN

**RAN1#102e**

Agreement:

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

Agreement:

The extension of maximal HARQ process number can be considered with following assumptions:

* The maximal supported HARQ process number is up to 32.
* FFS: Support on the maximal HARQ process number is up to UE capability

Minimizing the impacts on specification and scheduling

**RAN1#103-e**

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

**Decision:** As per email decision posted on Nov.13th,

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

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

**RAN1#104-e**

Final summary in [R1-2102143](file:///C%3A%5CUsers%5Ccarmela.c%5CAppData%5CLocal%5CTemp%5CDocs%5CR1-2102143.zip)

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.

* Working assumption: X = T\_proc,1
* FFS: Whether X should be changed to X = max(T\_proc,1, K1) where K1 is the minimum k1 if it is configured, otherwise k1 = 0
* Note: The TB of the two PDSCHs can be either same or different

Agreement:

For Type-2 HARQ codebook in NTN: Reduce codebook size with HARQ-ACK codebook only including 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