3GPP RAN WG2 Meeting #121bis-e R2-2304245

eMeeting April 17th – 26th, 2023

Agenda Item: 7.7.2

Source: InterDigital (Rapporteur)

Title: [DRAFT] Report of [AT121bis-e][105][NR NTN enh] Coverage enhancements

Document for: Discussion, Decision

# Introduction

This document is intended address contributions on coverage enhancements for non-terrestrial networks submitted to AI 7.7.2, as per the following:

**[AT121bis-e][NR NTN enh][105] Coverage enhancements (InterDigital)**

* Initial scope: Discuss the proposals in the submitted contributions in AI 7.7.2
* Initial intended outcome: Summary of the offline discussion with e.g.:
  + List of proposals for agreement (if any)
  + List of proposals that require online discussions
  + List of proposals that should not be pursued (if any)

Please note the following deadlines:

* Deadline for companies' feedback: **Monday 2023-04-24 18:00 UTC**
* Deadline for rapporteur's summary (in R2-2304245): Monday 2023-04-24 20:00 UTC

# Rel-18 NTN coverage enhancements in RAN2

In terrestrial networks the gap between a MAC entity stopping the *ra-ResponseWindow* and starting thera-ContentionResolutionTimer is usually quite brief (maybe one or a few slots [5]), allowing near-continuous monitoring of PDCCH. By offsetting the start of the ra-ContentionResolutionTimer in NTN this gap is significantly increased, limiting the ability to quickly receive a blind Msg3 retransmission grant after the *ra-ResponseWindow* is stopped (Figure 1).

Diagram, timeline

Description automatically generated

**Figure:** (A) Msg3 blind retransmission grant reception in a terrestrial network; (B) Msg3 blind retransmission grant reception in a non-terrestrial network;

## Support for enhanced to blind MSG3 retransmission

Possible previously identified impacts due to the current timer handling include the following:

* The additional delay means the network may not schedule a blind MSG3 retransmission until at least UE-gNB RTT after initial transmission, limiting scheduler flexibility and possibly increasing latency of the RA procedure.
* MSG3 repetition may not always be a suitable solution in NTN considering the RACH congestion caused by large number of UEs simultaneously performing RACH (e.g. feeder-link switch), which can place limitations on the resources needed to perform multiple consecutive repetitions.

Based on this, the following agreement was reached in RAN2#120:

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| **Agreement:**  RAN2 will consider enhancements to enable initial blind Msg3 retransmission grant reception in Rel-18 NTN |

The following summarizes RAN2#121bis-e contributions discussing this issue:

**Support additional enhancements [1] [4] [5]**

Proponents note the following:

* Can be used jointly or independently with MSG3 repetition feature to further improve coverage in the NTN environment, especially for UEs which don’t support MSG3 repetition. [1]
* Can easily extend solutions for MSG3 repetition (e.g. using spare bits in the IE *featureCombination*) to avoid interoperability issues. [4]
* Enhancements for additional monitoring are simple/straightforward to implement [5]

**Not additional specification needed [2] [3] [6]**

Opponents note the following:

* Additional gains over existing mechanisms (e.g., MSG3 repetition) are not clear. [2] [6]
* Brings additional complexity, protocol impacts, UE power consumption and DCI scheduling overhead [2]
* Additional solutions (e.g. feature support indication, RACH partitioning) may be needed to avoid interoperability issues, which can have large specification impacts. [2] [3]

Please also note the following chair guidance:

*No need to argue that initial blind msg3 retx this is currently not part of the WID. This is understood. But at the same time we agreed to continue the discussion on whether to have this, so this is what we will be doing*.

**Question 1) Do you support enhancements to enable initial blind Msg3 retransmission grant reception in Rel-18 NTN?**

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| **Company** | **Yes/No** | **Additional comments** |
| CATT | No | Actually, we have the concern on whether this brings benefits comparing with Rel-17 Msg3 repetition.  Firstly, in order to indicate that the UE supports/requests initial blind msg3 retx, the separate PRACH resources have to be configured. This definitely brings PRACH segmentation.  Then, the network schedules msg3 in RAR and potential blind msg3 retx in the subsequent PDCCH. Compared with Rel-17 Msg3 repetition, which indicates Msg3 repetiton number in RAR grant, the UE has to monitor the subsequent scheduling in PDCCH, which brings extra signalling overhead in PDCCH and power consumption for the UE.  Thirdly, in order to perfrom PDCCH monitoring, some window mechanisms need to be introduced which anyway brings sepc impacts.  In summary, we have not find benefits for initial blind Msg3 retx. |
| OPPO | Yes | Since Msg3 repetition is an optional UE capability for Rel-17 NR UEs, in case this feature is not supported by a UE, blind scheduled Msg3 retransmission can be used instead. That’s the reason why RAN2 specified enhancements to enable blind scheduling for Msg3 retransmission in Rel-17 NR NTN on top of Msg3 repetition. We understand the motivation to enable blind scheduling for initial Msg3 transmission is the same as that to enable blind scheduling for Msg3 retransmission, which should be supported in Rel-18 NR NTN. |
| LG | No | Agree with CATT.  In addition, as explained in our paper, the UE supporting Rel-17 may not stop the RAR window after reception of the RAR. With this, the UE may receive the UL grant for initial Msg3 blind retransmission. In other words, the UE supporting Rel-17 can support the reception of the initial Msg3 blind retransmission. (Maybe we can clarify that the RAR window is not stopped for NTN UE using note.) |
| vivo | No | In short, the unclear gain from this feature is not worth exchanging the complexity (i.e. RACH partitioning) it brings to resolve the inter-operabilty/co-existence issue which is even acknowledged by the proponents. Also, previous RAN2 agreement just says “RAN2 will **consider** the enhancement…”, but does not say RAN2 already agreed to introduce any enhanced solution with Spec impact. |
| Huawei, HiSilicon | No | Msg3 repetition was introduced in the R17 coverage enhancements WI. The network can already provide the UE with several transmission resources for Msg3 transmission in RAR if needed, which has a similar effect to the blind Msg3 retransmission.  We don’t see the gain of the proposed solutions compared to what is already specified. At the same time there are several drawbacks:   * extra scheduling overhead since the retransmission resource needs to be indicated * higher UE power consumption on PDCCH monitoring if longer timers are involved * additional mechanisms for the UE and the network to align on whether the enhanced operation is supported (e.g. RACH partitioning) * significant specification impacts |
| Apple | No | Agree with CATT.  The performance of blind Msg3 retransmission is same as R17 Msg3 repetition. Therefore, we do not see the need to introduce blind Msg3 retransmisson enhancement in R18. |
| Intel | No | This is not in R18 NR NTN scope, actually there is no RAN2 specific coverage enhancement in WID.  *In WID:*  *The detailed objectives are for NTN:*  *•To specify PUCCH enhancements for Msg4 HARQ-ACK (e.g. repetition) [RAN1, RAN4]*  *•To specify if necessary, enhancements to the Rel-17 procedures for DMRS bundling for PUSCH taking into account NTN-specifics (e.g. time-frequency pre-compensation) [RAN1]* |
| Thales | No | Agree with Huawei, the coverage benefit brings by blind msg3 retransmission is unclear while it comes with several drawbacks for signalling overhead and UE power consumption. |
| Samsung | No | Even though Msg3 repetition is an optional feature, supporting initial blind Msg3 retx grant should also be optional considering the following identified method to support it. Why do we need an optional feature whose function has already been supported by an existing optional feature? |
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## Method to support additional monitoring

The following methods have been proposed to support additional monitoring for blind MSG3 retransmission grant in NTN. A summary of pros/cons specific to each solution have been provided below, however companies are encouraged to review referenced contributions for additional details.

**Option 1) Introduce a new window/timer to control additional monitoring [4] [5]**

*Pros:*

* Additional flexibility would be useful to address the variety of deployment scenarios and coverage conditions in NTN, supporting a trade-off between UE power saving and additional scheduling opportunities [4]
* The simplest solution, and by using a new timer we avoid issues with expiry of CR timer – had CR timer been used for this issue [5]

*Cons*

* Brings additional protocol impacts [2]

**Option 2) Start ra-ContentionResolutionTimer immediately after end of initial MSG3 transmission [1]**

*Pros:*

* The most straightforward way [1]

*Cons:*

* Brings additional protocol impacts [2]
* If timer duration is less than UE-gNB RTT, starting ra-ContentionResolutionTimer immediately after initial Msg3 transmission will cause premature Contention Resolution failure if a blind Msg3 retransmission grant is not received [4]

**Option 3) Not stopping ra-ResponseWindow (e.g., via UE implementation) [6]**

*Pros:*

* No specification change needed to support solution (except maybe a note). The current MAC specification allows the UE to already monitor for blind retransmission grant by not stopping *ra-RespondWindow*. [6]

*Cons:*

* Due to large differential delay in NTN, continuing ra-ResponseWindow after RAR reception will have limited benefit for UEs at cell edge (a main candidate for coverage enhancements). [4]

Companies are invited to indicate the preferred option(s) to support additional monitoring.

**Question 2) Which of the following Option(s) do you support to control additional monitoring for blind MSG3 retransmission grant in NTN?**

* **Option 1: Introduce a new monitoring window;**
* **Option 2: UE starts *ra-ContentionResolutionTimer* immediately after the end of initial Msg3 transmission;**
* **Option 3: Not stopping *ra-ResponseWindow* (e.g., via UE implementation)**
* **Option 4: Other, please describe.**

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| **Company** | **Preferred Option(s)** | **Additional comments** |
| OPPO | Option 2 | We prefer to follow legacy to use ra-ContentionResolutionTimer for monitoring the MSG3’s retransmission grant. |
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## Requesting blind MSG3 retransmission

To avoid unnecessary power consumption and possible inter-operability issues, it would be helpful if UE has the knowledge of network’s capability so that UE could decide whether the additional PDCCH monitoring is needed. For both UE and network, this capability should be informed to each other before Msg3 transmission [1].

It is proposed in [1] and [4] that this can be achieved by introducing separate RO(s) and/or preamble(s) for this feature.

* Proponents note that a similar solution to MSG3 repetition can be adopted. Considering the IE *FeatureCombination* used to indicate msg3-repetitions (or combination of features) has multiple spare values, this could be a simple modification over the existing specification. [4]
* Opponents note that such RACH partitioning will bring extra huge standard work, and that RAN1 may also need to be involved in evaluating the RACH performance. Furthermore, coexistence between the feature of initial blind Msg3 retransmission and other features (e.g., Msg3 repetition, SDT) shall also be discussed. [3]

Companies are invited to comment on whether to support separate RACH resources for requesting blind retransmission for initial MSG3 transmission in NTN (i.e., similar to MSG3 repetition).

**Question 3a) Similar to MSG3 repetition, do you agree to introduce sepate RACH resources (e.g., RO(s) and/or preambles) for requesting blind MSG3 retransmission in NTN?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| OPPO | Agree | As the support of blind retransmission for initial Msg3 transmission requires changes for both UE and network, UE should be notified that network supports this feature and network should be able to know UE has requested the feature. The most simple and straightforway way to meet the above purposes is to introduce separate RO(s) and/or preamble(s) for this feature. |
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Another issue is ensuring UEs only perform additional monitoring when necessary (e.g. when the UE is coverage limited). This is addressed in MSG3 repetition by optionally restricting the UE to only request MSG3 repetition via separate RACH resources when the RSRP of DL path-loss reference is lower than a configured threshold *rsrp-ThresholdMsg3*.

Both [1] and [4] note that a similar solution can be used in NTN to request blind msg3 retransmission, and may also consider other thresholds based on NTN specific information (e.g., distance threshold from a cell reference point).

**Question 3b) Which of the following Option(s) do you support to control when a UE can request blind MSG3 retransmission?**

* **Option 1: An RSRP threshold (e.g., similar to MSG3 repetition);**
* **Option 2: A distance threshold;**
* **Option 3: Other, please describe.**

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| **Company** | **Preferred Option(s)** | **Additional comments** |
| OPPO | Option 1 | We think the feature of blind retransmission for initial Msg3 transmission can work in a similar manner, i.e. introduce a RSRP threshold for requesting blind retransmission for initial Msg3 transmission. The UE only uses the RACH resource requesting blind retransmission for initial Msg3 transmission if the UE’s RSRP measurement is below the threshold. Otherwise, the UE uses the legacy RACH resource and does not start ra-ContentionResolutionTimer immediately after the end of initial Msg3 transmission, so that unnecessary UE power consumption can be avoided.  Regarding whether to introduce distance-based criterion on top of RSRP-based criterion, this has been discussed in Rel-17 NR NTN WI for RACH type (i.e. 2-step or 4-step) selection, and RAN2 agreed not to consider such enhancement. So we think no need to introduce distance-based criterion here, either. |
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Finally, upon requesting blind MSG3 retransmission, a default behaviour could be to always perform additional monitoring (e.g., via starting the new monitoring window). However, since the network is not required to provide a blind retransmission grant even if requested, the UE may still end up monitoring for no reason.

[4] notes that one way to avoid this is to have some form of acknowledgment/confirmation in the RAR to notify the UE a blind MSG3 retransmission grant is expected. However, it is also noted this may require RAN1 involvement, and RAN2 should discuss the pros and cons of such a solution.

**Question 3c) What is the preferred UE behaviour after requesting blind MSG3 retransmission?**

* **Option 1: UE always starts monitoring for blind MSG3 retransmission grant after request;**
* **Option 2: UE only monitors after NW confirmation/indication in RAR (FFS details);**
* **Option 3: Other, please describe.**

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| **Company** | **Preferred Option(s)** | **Additional comments** |
| OPPO | Option 1 | For option2, we fail to see the need for NW to indicate in RAR. |
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## Other triggers for additional monioring

[4] notes that although the decision to schedule additional blind MSG3 retransmission grant(s) is up to NW, there are some scenarios where it is more likely, like after a failed reception or decoding of a previous message. Although UE may not always know a message was unsuccessfully received since feedback is limited during random access, there are some scenarios like fallback from 2-step to 4-step RACH where it will.

A UE which initated 2-step RACH falls back to 4-step RACH upon reception of a RAR instead of MSGB, indicating issues decoding the full MSGA on the NW side. To be conservative, a UE may trigger additional monitoring for blind MSG3 transmission grant to ensure subsequent messages are successful.

**Question 4) Do you agree that upon fallback from 2-step to 4-step RACH, UE performs additional monitoring for blind MSG3 retransmission grant in NTN?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| OPPO | Disagree | UE would fall back from 2-step to 4-step RACH in the following cases:  Case 1: upon reception of a RAR instead of MsgB;  Case 2: the attempt number of MsgA reaches the maximum attempt number  For case 1, UE shall send Msg3 based on the UL grant indicated in RAR and continue to monitor PDCCH. As we discussed in Q3, UE needs to request blind Msg3 retransmission by using separate RO/preamble, otherwise network could not be aware of whether UE monitors for blind Msg3 retransmission after Msg3 initial transmission. Obviously, upon reception of a RAR instead of MsgB, UE has no way to inform network whether it would monitor for blind Msg3 retransmission or not. So triggering additional monitoring may have inter-operability issue.  For case 2, based on the current spec, UE would not perform selection of the set of random access resources. That is, for Msg3 repetition feaure, if UE firsly selects 2-step RACH, and then falls back to 4-step RACH due to the attempt number of MsgA reaching the maximum attempt number, the UE would not select the random access resources indicating Msg3 repetition. We think that for blind Msg3 retransmission for Msg3 initial transmission, it should work in the same manner as the feature as Msg3 repetition. |
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## Others

**Question 5) Companies may list any other coverage enhancement-related issues that should be discussed in the table below.**

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| **Company** | **Additional comments** |
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# Conclusions

<To be generated based on company input>

# References

1. [R2-2302536](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2302536.zip) Discussion on initial blind Msg3 retransmission for NTN OPPO
2. [R2-2302798](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2302798.zip) Discussion on blind Msg3 retransmission Huawei, HiSilicon
3. [R2-2303326](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303326.zip) Discussion on coverage enhancement for R18 NTN vivo
4. [R2-2303727](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303727.zip) Blind Msg3 retransmission in Rel-18 NTN InterDigital
5. [R2-2303834](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303834.zip) R18 NR NTN Coverage enhancements Ericsson
6. [R2-2303997](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303997.zip) Discussion on inital blind Msg3 retransmssion LG Electronics Inc.

# Appendix: Relevant proposals

**Proposals relevant for Question 1)**

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| **Contribution** | **Relevant proposal(s) – No spec change needed** | **Company** |
| [2] [R2-2302798](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2302798.zip) | **P1:** Enhancements for initial blind Msg3 retransmission are not pursued in Rel-18 NTN. | Huawei, HiSilicon |
| [3] [R2-2303326](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303326.zip) | **P1:** Not pursue any spec change to support the initial blind Msg3 retransmission in Rel-18 NR NTN. | vivo |
| [6] [R2-2303997](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303997.zip) | **P1:** It is up to UE implementation to monitor the PDCCH by not stopping ra-RespondWindow in order to receive the initial blind Msg3 retransmission grant (No specification change is needed). | LG electronics |

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| **Contribution** | **Relevant proposal(s) – Support enhancements** | **Company** |
| [1] [R2-2302536](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2302536.zip) | **P1:** RAN2 confirms that enhancements to enable blind retransmission for initial Msg3 transmission is supported in Rel-18 NR NTN. | OPPO |

**Proposals relevant for Question 2)**

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| **Contribution** | **Relevant proposal(s) – Methods to support additional monitoring** | **Company** |
| [1] [R2-2302536](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2302536.zip) | **P2:** To enable blind retransmission for initial Msg3 transmission, UE starts ra-ContentionResolutionTimer immediately after the end of initial Msg3 transmission. | OPPO |
| [4] [R2-2303727](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303727.zip) | **P1:** Introduce a new monitoring window to control additional PDCCH monitoring for blind MSG3 retransmission grant in NTN. | InterDigital |
| [5] [R2-2303834](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303834.zip) | **P1:** A new timer initialBlindRetxTimer is started by the UE after successful reception of a Random Access Response containing Random Access Preamble identifiers that matches the transmitted PREAMBLE\_INDEX.  **P2:** Monitor the PDCCH while the initialBlindRetxTimer is running regardless of the possible occurrence of a measurement gap | Ericsson |
| [6] [R2-2303997](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303997.zip) | **P1:** It is up to UE implementation to monitor the PDCCH by not stopping ra-RespondWindow in order to receive the initial blind Msg3 retransmission grant (No specification change is needed). | LG electronics |

**Proposals relevant for Question 3a)**

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| **Contribution** | **Relevant proposal(s) – Requirements to request blind retransmission** | **Company** |
| [1] [R2-2302536](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2302536.zip) | **P3:** Introduce separate RO(s) and/or preamble(s) for the feature of blind retransmission for initial Msg3 transmission in NTN. | OPPO |
| [4] [R2-2303727](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303727.zip) | **P2:** Similar to MSG3 repetition, UE can request blind MSG3 retransmission via use of separate RACH resources. | InterDigital |

**Proposals relevant for Question 3b)**

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| **Contribution** | **Relevant proposal(s) – Requesting blind MSG3 retransmission** | **Company** |
| [1] [R2-2302536](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2302536.zip) | **P4:** Introduce a RSRP threshold for determining when to select RACH resources requesting blind retransmission for initial Msg3 transmission in NTN. | OPPO |
| [4] [R2-2303727](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303727.zip) | **P3:** Similar to MSG3 repetition, the ability for UE to request blind MSG3 retransmission can be subject to satisfaction of conditions (e.g., RSRP or distance based). FFS details. | InterDigital |

**Proposals relevant for Question 3c)**

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| **Contribution** | **Relevant proposal(s) – Methods to support additional monitoring** | **Company** |
| [4] [R2-2303727](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303727.zip) | **P4:** RAN2 to discuss whether UE always starts monitoring for blind MSG3 retransmission after sending a request, or after NW confirmation/indication in RAR. | InterDigital |

**Proposals relevant for Question 4)**

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| **Contribution** | **Relevant proposal(s) – Methods to support additional monitoring** | **Company** |
| [4] [R2-2303727](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303727.zip) | **P5:** Upon fallback from 2-step to 4-step RACH, UE performs additional PDCCH monitoring for blind MSG3 retransmission grant in NTN | InterDigital |