3GPP TSG-RAN WG2 Meeting #117 Electronic R2-22xxxxx

Elbonia, 21st of Feb – 3rd of Mar 2022

**Agenda item: 8.10.3.2.1**

**Source: Nokia, Nokia Shanghai Bell**

**Title: Report from [AT117-e][108][NTN] CHO open issues (Nokia)**

**WID/SID: NR\_NTN\_solutions-Core - Rel-17**

**Document for: Discussion and Decision**

# 1 Introduction

The scope of this paper is as follows:

**[AT117-e][108][NTN] CHO open issues (Nokia)**

Initial scope: Discuss open issues for CHO based on company contributions in AI 8.10.3.2.1

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)

Initial deadline (for companies' feedback): Tuesday 2022-02-22 0800 UTC

Initial deadline (for rapporteur's summary in R2-2203536): Tuesday 2022-02-22 1000 UTC

The CHO details are handled in the following sections.

# 2 Discussion

This section is divided topic-wise, based on what has been contributed by the companies.

## 2.1 On simultaneous configuration of time-based and location-based CHO execution conditions

This aspect has been discussed for multiple meetings already, but apparently no formal and final decision was taken. Several papers submitted to RAN2#117 try to address this issue, e.g. [4][5][6]. Rapporteur thinks there may not be a solid use case which would justify such combination, in addition to the measurement events Ax. However, companies are asked to clarify whether they see a need for such joint time-based and location-based triggering. Please provide a use case where this would be especially desirable.

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| **Question 1: Do you support joint time-based and location-based CHO triggering? If yes, please provide a use case, where this would be particularly helpful.** | | |
| **Company** | **Answer** | **Comments** |
| Ericsson | no | **Can be further discussed in rel-18 if needed** |
| Sony | No | **We think these events are anyway configured together with radio measurements so we don’t see a strong need for joint configuration.** |
| NEC | Neutral | **We do not see a solid use case at this moment.**  **On the other hand, we do not see benefit to have specification restriction. It is better to leave it to network implementation to configure this combination or not. moreover, It is possible that to replace a trigger combination of timer-based +Ax with a trigger combination of timer-based +location-based, considering the correlation between Ax and location-based trigger.** |
| Qualcomm | No |  |
| Apple | No |  |
| OPPO | No | It is not necessary to configure location-based and time-based CHO conditions simultaneously, since the joint configuration of location and RSRP as well as time and RSRP triggers is enough to avoid the CHO issues due to small RSRP/RSRQ variation in regions of cell overlap in NTN. |
| Lenovo | No | Currently, we don’t see the use case. |
| Huawei, HiSilicon | No | For moving cell scenarios, the network needs to know the UE location to configure the T1 and T2 in the time based CHO, which has the same effect as location based CHO, therefore no need to configure both.  For the quasi-earth fixed cells, we think the time based CHO is more efficient than the location based CHO, because the new cell will cover the same area with the previous cell. For the GEO cell, we think only location based CHO will be used because the satellite is serving the same area continuously.  The only use case to configure both could be: in the fixed cell scenario, the UE has a fast speed and is likely to move out of the coverage before the current cell stops serving, but this does not look like a common case. |
| ITRI | No | However, when the start serving time of candidate cells are not provided to UE, joint time-based and location-based CHO triggering allows UE performing measurements of visible neighbour cells. We’d like to support further discussion in Rel-18. |
| Samsung | No |  |
| vivo | No | We understand the intention of both location-based trigger condition and time-based trigger condition is to reduce the possibility of CHO failure due to inaccuracy of RRM measurement; so configuring either of the two is already sufficient to realize such a goal. |
| Xiaomi | No | No common use case. |
| CATT | No |  |
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## 2.2 On the behavior at T2 if UE does not execute CHO

Another topic widely addressed in the papers to RAN2#117 concerns the UE behavior at T2, defining the end of the time window for CHO execution. In some papers (e.g. [5][10]) it is suggested those CHO configurations are released at T2, while in other papers ([1][7][8]) it is claimed those configurations can be kept and used for potential recovery. This area requires more clarity and at least the following issues should be resolved: is CHO Recovery supported for NTN UEs? What happens when the UE does not execute CHO at T2 (e.g. RLF?). What happens with the target cell’s CHO configurations at T2? Please answer those questions in the following tables.

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| **Question 2: What happens when the UE does not execute CHO at T2? Consider at least the following:**   1. **The UE encounters Radio Link Failure (RLF)** 2. **The UE continues the operation in the source cell/evaluates other possible CHO conditions** 3. **Other** | | |
| **Company** | **Answer** | **Comments** |
| Ericsson | Depends but option b is closest | **T2 is per candidate serving cell and not per UE in the time based CHO what we ended up agreeing. Afetr T2 UE should not consider that candidate target cell anymore.** |
| Sony | b) | It makes sense for UE to keep those configurations and evaluate the pre-configured conditions rather than re-establishing the radio link. We can discuss if any other additional conditions may be applied. |
| NEC | a) maybe b) | **Depending on scenario:**  **Assume T1/T2 is configured for a service link switch, then current serving cell would disappear around this time point, a) would happen.**  **Assume T1/T2 is configured for a neighbouring cell visibility time window, then b) may be the case. But we are not sure that this is the scenario where timer-based trigger would be applied in our designing intention.** |
| Qualcomm | b) | There can be other CHO commands for which T2 has not expired. |
| Apple | Maybe a or b or c | The UE may or may not encounter RLF just because it was unable to execute CHO at T2 if source cell was available. Of course, it also possible for the UE to handover to a different cell based on CHO configuration. |
| OPPO | b) or a) | In any case, UE keeps CHO configurations and there is no spec impact. |
| Lenovo | B with comments  C | For a, CHO may have multiple cells. If one CHO cell is not triggered, another one CHO cell could be triggered.  For b, if b implies that UE stops evaluating CHO condition after T2, we can support b.  For c, UE stops evaluating CHO condition e.g A3, or A5. |
| Huawei, HiSilicon | b | Agree with Ericsson. |
| ITRI | b | UE should not consider the candidate cell. UE could evaluate CHO execution condition of other configured candidate cells if available.  We think RLF should be determined based on the serving cell radio link condition. |
| Samsung | b | UE continues to evaluates other candidate cells. |
| vivo | b) | Since T2 is configured per candidate cell, when T2 of a candidate cell expires, the UE can continue to evaluate other candidate cells whose T2 does not expire. |
| Xiaomi | b) | After T2, UE just don’t need to consider the candidate cell for CHO. If configured multiple CHO candidate cells, b can be supported, |
| CATT | b) | Several CHO configurations may have been configured, so if one CHO configuration is not triggered, maybe another one has been or will be triggered.  For a), RLF should be judged by RLM, rather than T2.  After T2, we just need to determine the corresponding candidate cell is invalid, and UE may maintain the connection with source cell, and evaluate the other candidate cells condition. |
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Irrespective of the answer to Q2, please share your view what happens with the CHO configurations at T2.

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| **Question 3: What happens with the CHO configuration at T2?** | | |
| **Company** | **Answer** | **Comments** |
| Ericsson | depends | **After last T2 UE should discard. After T2 of particular cell UE should not consider that cell as network would not reserve the resources after T2.** |
| Sony |  | **The configurations should be kept.** |
| NEC | Delete it | **Since we assume that after T2, CHO to target cell would not be allowed anymore and then HO preparation at target cell may be deleted, then UE should also delete the CHO configuration at T2** |
| Qualcomm | Discard | Either the candidate cell has released reserved resources at T2 or the candidate cell has moved away or is about to move away/stop at T2. In either case, it is better not to use the CHO after T2. |
| Apple | Delete |  |
| OPPO | Keeping CHO configuration after T2 | Similar to legacy, if UE is initiated to execute CHO but fails to handover to target cell, the CHO configuration could be used for CHO based handover failure recovery in RRC connection re-establishment procedure, if network allow to do so. It is beneficial that UE keeps the CHO configuration even after T2. Therefore, no need to introduce new behaviour to release the CHO configuration at T2. |
| Lenovo | Stop evaluating CHO condition | The CHO configuration can be kept for recovery as legacy. |
| Huawei, HiSilicon | Delete | UE can delete the time based CHO configuration after T2, and the source node can configure new CHO configuration and does not need to send the RRC reconfiguration message to cancel the invalid CHO configuration. Besides, the reserved resources can be released. |
| ITRI | UE could keep the configuration | Though the configuration should not be considered for CHO after T2, UE could utilize the configuration e.g., when the cell is selected for RLF handling. |
| Samsung | Delete | Agree with Qualcomm. Even if to be used for CHO recovery, the UE should consider the configuration valid only before T2. |
| vivo | Release | It is not preferable for a candidate target cell to reserve the resources for a long time, especially unreasonable for the cell to keep the resources after T2, with the UE not possibly triggering CHO to that cell anymore. |
| Xiaomi | Keep the CHO configuration | Agree with OPPO. CHO trigger including location or time event can also be used for failure recovery. No new behaviour is needed to release the CHO configuration at T2. |
| CATT | See the comments | Just as legacy, the CHO configuration can be kept until the network deletes it via signalling. |
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And finally whether the NTN UE, supporting CHO, can be configured with CHO Recovery? If it can, then perhaps it makes sense not to delete the CHO configurations even at T2.

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| **Question 4: Can the NTN UE supporting CHO, be configured with CHO Recovery? Please share the details how this may work beyond time T2.** | | |
| **Company** | **Answer** | **Comments** |
| Ericsson | Yes, but see comments. | If T2 has not expired, the UE should be able to re-use the CHO configuration in a re-establishment procedure in case of RLF in the source cell or in the target cell (provided the UE has been configured with the *attemptCondReconfig*). |
| Sony | Yes |  |
| NEC | Yes | **Agree with Ericsson.**  **To fully use CHO configuration and shorten the recovery interruption, we prefer to support CHO recovery in NTN.**  **At the same time, we think timer-based CHO recovery would be only applicable before T2** |
| Qualcomm | Yes | But agree with Ericsson, this may not work beyond T2. |
| Apple | Yes |  |
| OPPO | Yes | Network could configure UE with the *attemptCondReconfig* to allow CHO recovery. |
| Lenovo | Yes |  |
| Huawei, HiSilicon | Yes, before T2 | Agree with Ericsson/NEC/QC that this is only for time duration before T2. |
| ITRI | Yes | Considering the CHO execution condition may be different from cell selection for RLF handling, UE could utilize the configuration for RLF handling. |
| Samsung | Yes but before T2 | We think the CHO recovery can only work before T2 as the reason in Q3. |
| vivo | Yes | Following the legacy procedure is sufficient. The *attemptCondReconfig* IE can be configured to allow CHO recovery. It should be noted that the CHO configuration of candidate cell whose T2 expires is not in the *VarConditionalReconfig* if RAN2 agrees that UE releases the CHO configuration for a candidate target cell at the associated T2, i.e., if the UE selects such a cell, the UE transmits the *RRCReestablishmentRequest* message instead of performing secondary CHO. |
| Xiaomi | Yes | Legacy procedure can be reused. If *attemptCondReconfig* is configured and the selected cell is the candidate cells, UE can apply the stored *condRRCReconfig* for failure recovery. UE perform cell selection to decide the selected cell in R16 RRC reestablishment. It can be reused in R17 without changes, |
| CATT | Yes | Agree with Ericsson. |
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## 2.3 On evaluating the CHO conditions in NTN

Few papers (e.g. [3][14]) also discuss the UE’s behavior concerning the time/location-based triggering and events Ax. I.e. whether the UE shall evaluate them only within the time window [T1, T2] or when the location condition is met? Or should it be left up to the UE implementation?

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| **Question 5: What is the expected UE behavior when it is configured with time- or location-based condition jointly with the RRM event Ax:**   1. **UE is required to evaluate event Ax only when the time-based or location-based condition is met** 2. **It is up to the UE implementation as long as it has RRM measurements within the time window [T1, T2] or when the location condition is met** | | |
| **Company** | **Answer** | **Comments** |
| Ericsson | b |  |
| Sony | b) | **This can be left for UE implementation and we don’t need to specify it.** |
| NEC | b | **We think this is in UE implementation scope** |
| Qualcomm | b |  |
| Apple | b) | It does not matter what order the UE evaluates the conditions |
| OPPO | b) with comment | When UE to start/stop evaluating the RRM condition evaluation of neighbour cell in connected mode depends on the s-measure mechanism.  In our understanding, for time-based condition for CHO, the legacy behaviour should be followed on. The only new behaviour needed to specify is that before T2, UE should start neighbour cell RRM measurement and it could be left to UE implementation.  However, for location-based condition for CHO, RRC condition evaluation and location-based condition evaluation are independent. No need to guarantee the RRM measurements when the location condition is met. |
| Lenovo | a) | In legacy for CHO, when to start/stop evaluating CHO condition is specified. e.g.  TS38.300:  The UE starts evaluating the execution condition(s) upon receiving the CHO configuration, and stops evaluating the execution condition(s) once a handover is executed.  TS38.331 (5.7.3b.2):  Upon initiating the fast MCG link recovery procedure, the UE shall  1> stop conditional reconfiguration evaluation for CHO, if configured;  1> stop conditional reconfiguration evaluation for CPC, if configured; |
| Huawei, HiSilicon | b |  |
| ITRI | b) | The CHO execution condition is considered as fulfilled when both RRM event Ax and time/location-based condition are met. But the evaluation of RRM event could be up to UE implementation. |
| Samsung | b |  |
| vivo | b) |  |
| Xiaomi | b) |  |
| CATT | b) |  |
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## 2.4 On the duration and granularity of T2

Some remaining Stage-3 details need to be resolved as well. One of them concerns the duration and granularity of T2. It has been decided that T1 is expressed as an absolute time value, while the T2 is a timer, started at T1. T2 should be long enough so that it covers large NTN footprints and allows the UE to be configured early. On the other hand, the rapporteur believes it does not have to be extremely accurate and the granularity of 10 or even 100 ms could be sufficient. Please share your opinion.

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| **Question 6: What is the preferred duration and granularity of timer T2?** | | |
| **Company** | **Answer** | **Comments** |
| Ericsson | The duration field should not only cover the “overlap time” between the old and the new candidate target cell, but also, to some extent, the visibility time of a neighbour cell as candidate target cell | **Would be good to get satellite companies views on exact values** |
| Sony | We are fine with 10ms or 100ms granularity |  |
| NEC | Duration: x seconds  Granularity: 20ms + | **In our understanding, timer-based trigger is mainly used for service link change case, but not used to indicate appearance /disappearance of a neighbouring cell as a target cell of CHO. Hence duration of T2 only needs to cover overlap time between existing and replacement cell (plus possible guard time), no need to be long enough to cover the visibility time of a neighbour cell as a target cell.**  **For granularity, we agree that it does not need to be very accurate 10 to 100ms looks fine** |
| Qualcomm | Align with cell stop time |  |
| Apple | Duration: in seconds  Granularity: 100ms is more than enough |  |
| OPPO | No strong view | **Would be good to get satellite companies views on exact values** |
| Huawei, HiSilicon | INTEGER (1..50000) with the unit of 10ms | According to TR 38.821, for LEO transparent payload, the satellite speed is 7.56 km/s, the maximum cell diameter is 3500km (i.e. HEO). For earth moving cell scenarios, the serving time of the cell from the moment it covers the UE to the moment it leaves the UE is about 463s, which can be rounded up to 500s. If the time-based CHO is configured soon after the UE is covered by the satellite, the maximum duration can be configured as 500s. For the quasi-earth fixed cell, since the upcoming cell covers the same area as the current serving cell, the serving cell can configure time-based CHO towards the upcoming cell to the UE when there is not much remaining serving time. In other words, there is no need for a large value for the CHO duration for quasi-earth fixed cell scenarios and 500s is definitely enough. Considering the unit of *duration-r17* is preferably the same as *t1-Threshold-r17*, and *t1-Threshold-r17* follows the same format of *timeInfoUTC* in SIB9 which is in the units of 10ms, the max value of *duration-r17* can be 500s / 10ms = 50000.  Therefore, the type of duration-r17 can be INTEGER (1..50000). |
| ITRI | Duration: in seconds  Granularity: 100ms |  |
| Samsung | Duration in seconds | fine with 10ms or 100ms granularity |
| vivo | Duration: x seconds  Granularity: 10 ms | For the duration, we think it should cover the visibility time of a candidate target cell.  For granularity, we think taking the granulation of duration as 10 ms is reasonable since T1 is represented by UTC whose granularity is 10 ms, but we can follow the majority’s view on this issue. |
| Xiaomi | We are ok to the granularity of 10ms or 100 ms | We think the duration of time based event should cover the largest serving time of candidate cells, |
| CATT | The granularity of 10 or even 100 ms seems enough. | About the duration of T2, because the serving time of cell to a certain place is affected by the satellite orbital altitude, the number of satellites on each orbital plane, cell diameter size, cell type (i.e. earth moving cell or quasi-earth fixed cell) and so on. These detail values may need clarification from satellite companies. |
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## 2.5 On the number of MeasIDs for the CHO

E.g. in [4][12] it is discussed whether the number of MeasIDs to be used for CHO execution triggering shall be increased. [4] proposes to extend it to 3, while [12] states it is acceptable to keep the existing limit. Please share your view on the maximum number of configurable MeasIDs in NTN CHO.

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| **Question 7: What is the maximum value of MeasIDs for NTN CHO that should be supported in Rel-17?** | | |
| **Company** | **Answer** | **Comments** |
| Ericsson | 2 or 3 | **Support of 3 MeasIDs shall only be considered if a justified use case can be provided.** |
| Sony | Keep the existing limit |  |
| NEC | 2 as existing limit | **Proponent**  **A timer or location-based trigger combines with an Ax trigger would be robust enough to trigger handover execution. Otherwise the exiting signalling needs to be extended** |
| Qualcomm | Keep the existing limit i.e., 2 |  |
| Apple | 2 |  |
| OPPO | 2 or 3 | We propose to discuss the potential combinations of three RSRP/RSRQ-based CHO events A3/A4/A5 as well as the time-based or location-based condition instead. Then how to capture it in spec, e.g. whether to extend the maximum value of MeasIDs for CHO, could be left to stage-3. |
| Lenovo | 3 | To ensure the robustness of mobility, legacy CHO supports A3&A5, A3&A3, A5&A5 besides the single A3 and single A5 from channel quality point of view. It is natural that we need to support all following combination as follows. Otherwise, it will degrade the mobility performance.   * Combined condition#3: location&condEventA3&condEventA3 * Combined condition#4: location&condEventA3&condEventA5 * Combined condition#5: location&condEventA5&condEventA5 |
| Huawei, HiSilicon | 2 | We don’t see a strong need to extend. |
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| ITRI | Keep the existing limit |  |
| Samsung | 2 |  |
| vivo | 3 | We share the same view with Lenovo. |
| Xiaomi | 3 | Agree with Lenovo. Combined condition#3~5 should be supported.  FFS: whether support the following combined conditions.   * Combined condition#6:   location(time)&condEventA4&condEventA4   * Combined condition#7:   location(time)&condEventA3&condEventA4   * Combined condition#8:   location(time)&condEventA5&condEventA4 |
| CATT | 2 | It is not necessary to support time/location together with two RRM conditions, or time and location and a RRM condition. 2 MeasIDs is enough for now. |
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## 2.6 Other

There are few other CHO-related proposals in the papers submitted to RAN2#117. E.g. [1][2] elaborate on the benefits of preparing multiple CHO candidates in advance and storing those CHO commands. Please kindly respond what other important aspects need to be addressed in Rel-17 NTN WI.

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| **Question 8: What other important CHO issues need to be discussed and decided in Rel-17 NTN? E.g.**   1. **Storing CHO commands for future candidate cells** 2. **Other UTC time+duration or UTC time +timer -----------Open issue 7: Procedural text may need to be updated in 5.3.5.13.4 Conditional reconfiguration evaluation (R2-2202587 Lenovo, [R2-2203153](file:///D:\\OneDrive%20-%20Lenovo\\3GPP\\RAN2\\TSGR2_117e\\Docs\\R2-2203153.zip) Ericsson)** | | |
| **Company** | **Answer** | **Comments** |
| Ericsson | unclear | CHO command may have 8 candidate target cells. What is meant by the proposal a? is this related to what should be done after respective T2 or last T2?  Additionally:  The proposal referred to in option a) has already been discussed in RAN2 with the conclusion not to proceed in present release.  The idea as such is interesting, but it should not be addressed in Rel-17. |
| Sony | a) | **We think storing CHO commands for future candidate cells can avoid such signalling taking place every few seconds with every HO for each UE in the cell.** |
| Qualcomm | a) | If candidate cells are the intra-gNB cells, this is feasible to keep their CHO commands until T2. This could be applicable scenario as satellite is transparent and gateway is likely to be same on the ground.  This will help reduce the signalling overhead. |
| Lenovo | B | The option of UTC time + duration/timer was agreed. But we have not decided which one (UTC time+duration or UTC time +timer) should be captured in the RRC specification.  In current running CR, UTC time + duration is captured. If UTC time + duration is captured, 5.3.5.13.4 will be updated and have a complicated change. see the potential change proposed by [R2-2203153](file:///D:\\OneDrive%20-%20Lenovo\\3GPP\\RAN2\\TSGR2_117e\\Docs\\R2-2203153.zip).  If UTC time +timer is captured, updating 5.3.5.13.4 is simple. see the potential change proposed by R2-2202587. Namely, ‘when timer is running’ is added in 5.3.5.13.4 compared to the legacy specification. In addition, If UTC time +timer is captured, the definition of condEventT1 can be removed. |
| Huawei, HiSilicon | b | According to the text proposals by R2-2203153 (Ericsson, UTC time + duration), the RRM conditions are only evaluated after time/location condition is met;  The text proposals by R2-2202587 (Lenovo, using a timer) does not address the location-based CHO procedures, and the procedure style is different from legacy text (in legacy text, the descriptions is organized by whether entering/leaving condition is met);  We also proposed an alternative in R2-2202886, where the multiple triggers are evaluated independently. |
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# 3 Conclusion

The following proposals have been made in this document:

**Proposals for agreement:**

**Proposal y:**

**Proposals for discussion:**

**Proposal x**

# References

1. R2-2202467 Remaining Rel-17 NTN open issues for CONNECTED mode Nokia
2. R2-2202565 Open issues in CHO Qualcomm Incorporated
3. R2-2202587 Consideration on open issues for CHO Lenovo, Motorola Mobility
4. R2-2202775 Open issues on CHO for R17 NR NTN vivo
5. R2-2202886 Remaining issues on CHO Huawei, HiSilicon
6. R2-2203005 Discussion on the RRC open issues in NTN OPPO
7. R2-2203051 Remaining NTN CHO issues LG Electronics France
8. R2-2203067 Discussion on RRC open issues for NTN Xiaomi Communications
9. R2-2203077 Further Discussion on the Open Issues of CHO CATT discussion Rel-17
10. R2-2203153 Remaining connected mode aspects for NTN Ericsson discussion
11. R2-2203154 [Pre117-e][NTN][101] RRC open issues Ericsson
12. R2-2203236 Remaining open issues of CHO NEC Telecom MODUS Ltd.
13. R2-2203301 Open issues on RRC aspects Samsung Research America
14. R2-2203422 Remaining RRC open issues in NTN InterDigital