**3GPP TSG-RAN WG2 Meeting #121bis-e draft R2-2304249**

**Online, Apr 17th-26th, 2023**

**Source: Samsung**

**Title: Report of [AT121bis-e][109][NR NTN Enh] RACH-less HO (Samsung)**

**Agenda item:** **7.7.4.2**

**Document for:** **Discussion and Decision**

# Introduction

This document records inputs and outcome for the following offline discussion.

* [AT121bis-e][109][NR NTN Enh] RACH-less HO (Samsung)

Initial scope: Continue the discussion on RACH-less HO, e.g. based on proposals in [R2-2303768](file:///C:\Data\3GPP\Extracts\R2-2303768.docx). Also discuss interactions between RACH-less HO and CHO

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)

Deadline for companies' feedback: Monday 2023-04-24 12:00 UTC

Deadline for rapporteur's summary (in R2-2304249): Monday 2023-04-24 18:00 UTC

Proposals marked "for agreement" in R2-2304249 not challenged until Tuesday 2023-04-25 08:00 UTC will be declared as agreed via email by the session chair (for the rest the discussion might continue online in the Tuesday CB session).

Participating delegates are encouraged to provide contact information in this table.

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| Company | Name | Email Address |
| Samsung | Shiyang Leng | shiyang.leng@samsung.com |
| CMCC | Yuzhen Liu | liuyuzhen@chinamobile.com |
| CATT | Xiangdong Zhang | zhangxiangdong@catt.cn |
| Thales | Flavien Ronteix | flavien.ronteix-jacquet@thalesaleniaspace.com |
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# Background

RAN2 has agreed to support RACH-less handover (HO) for NTN for Rel-18 HO enhancement. The following agreements have been made on RACH-less HO.

Agreements 121:

1. Support RACH-less Handover in Rel-18.
2. RACH-less Handover in NR NTN is a L3 mobility procedure (FFS if this is combined with the unchanged PCI approach, if supported) and uses the LTE’s RACH-less Handover procedure as a baseline. FFS on TA acquisition
3. In NTN RACH-less handover, network indicates (implicitly or explicitly) whether NTA in the target cell is identical to the source cell or explicitly provided by the NW.
4. Support dynamic grant from the target cell for RACH-less PUSCH transmission to reduce random access congestion in the target cell. FFS whether to limit the solution to same feeder link/gateway scenario

Agreements 121bis-e:

1. In Rel-18 we don’t aim at RACH-less HO for NTN-TN mobility
2. For initial UL transmission in RACH-less HO, support pre-allocated grant in RACH-less HO command

# Discussion

## Applicable scenarios

For RACH-less HO, UE has to perform UL synchronization without RA. As specified in TS 38.211 and TS 38.213, UE calculates TA, i.e., , for the first UL transmission, where

* is configured by parameter *n-TimingAdvanceOffset* or a default value is used if not configured,
* is configured by common TA parameter,
* is computed based on UE location and ephemeris.

The only uncertainty is . In LTE RACH-less, two cases are supported: N\_TA equals 0 and N\_TA equals a source serving cell. To check the feasibility for NTN, RAN2 have listed all 4 scenarios and asked RAN1 and RAN4.

1. Intra-satellite handover with the same feeder link. i.e., with same gateway/gNB
2. Intra-satellite handover with different feeder links, i.e., with gateway/gNB switch
3. Inter-satellite handover with gateway/gNB switch
4. Inter-satellite handover with same gateway/gNB

RAN1 and RAN4 have replied respectively in R2-2300020 and R2-2301998 as follows.

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| **RAN1 response**  For scenario (1), from RAN1 perspective the RACH-less handover is possible, assuming the following notes can be satisfied, when UE UL transmission synchronization can be maintained by applying pre-compensation using the assistance information, e.g., epoch time, ephemeris, common TA, of the target cell.  For scenario (2)-(4), from RAN1 perspective the RACH-less handover may be possible, assuming the following notes can be satisfied, when UE UL transmission synchronization can be maintained by applying pre-compensation using the assistance information, e.g., epoch time, ephemeris, common TA, of the target cell.  Note 1: RAN1 assumes that the RAN4 UL synchronization requirement specified in Table 7.1C.2-1 of TS38.133 applies to the first UL transmission in the target cell.  Note 2: gNB is expected to provide valid assistance information of the target cell to UE.  Note 3: gNB is expected to ensure the UE can perform the UL transmission while respecting common TA and UE processing time.  **To RAN2:**  RAN1 respectfully asks RAN2 to take the above response into account in the future work.  **To RAN4:**  RAN1 respectfully asks RAN4 whether RAN1’s assumption in Note 1 is correct. |

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| RAN4 would like to thank RAN1 for the liaison in R1-2213001 regarding RACH-less handover in NTN.   * For NTN-NTN FR1-FR1 handover, RAN4 confirms that Note 1 in the LS (R1-2213001) is correct, i.e. the timing requirement specified in Table 7.1C.2-1 of TS 38.133 applies to the first UL transmission, including PUCCH, PUSCH, SRS, PRACH, and msgA, in the target cell, provided that * At least one SSB is available at the UE during the last 160 ms. * UE is provided with information such that the UE has valid and upon handover execution. * The network and UE have a common understanding of NTA component upon HO execution. * RAN4 assumes the determination of the value for NTA for the different scenarios is up to RAN1. * The timing requirement specified in Table 7.1C.2-1 of TS 38.133 are applicable to FR1 only and there are no requirements for other frequency ranges. * There are no existing RAN4 NR RRM requirements for RACH-less HO and additional RAN4 work will be required to introduce requirements and identify side conditions.   **To RAN1**  **ACTION:** RAN4 respectfully asks RAN1 to take the above information into consideration in their future work. |

RAN4 confirms UL synchronization requirements, which includes the requirement for N\_TA, i.e., the network and UE have a common understanding of N\_TA component upon HO execution. This can be satisfied by RAN2 agreement.

1. In NTN RACH-less handover, network indicates (implicitly or explicitly) whether NTA in the target cell is identical to the source cell or explicitly provided by the NW.

RAN4 also assumes the determination of the value for N\_TA for the different scenarios is up to RAN1.

RAN1 confirms given the RAN4 requirement is satisfied, scenario (1) is possible and scenario (2-4) may be possible.

Based on these, NTN RACH-less HO for scenario (1) is more possible than for scenario (2-4). From UE perspective, there is no difference to support RACH-less UL synchronization in different scenrios. From NW perspective, N\_TA has to be indicated to configure RACH-less HO. So it is proposed to confirm the applicable scenarios.

**Q1) Do you agree the following proposal?**

* **NTN RACH-less HO is supported for Intra-satellite handover with the same feeder link. i.e., with same gateway/gNB;**
* **NTN RACH-less HO can be supported for intra-satellite handover with different feeder links, i.e., with gateway/gNB switch, inter-satellite handover with gateway/gNB switch, and inter-satellite handover with same gateway/gNB.**

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| **Company** | **Yes/No** | **Comments** |
| Samsung | Yes |  |
| CMCC | Yes |  |
| CATT | Yes | We share the same view as Rapporteur that NTN RACH-less HO for scenario (1) is more possible than for scenario (2-4) based on LSes from RAN1 and RAN4. |
| vivo | See comments | We agree the first bullet. For other scenarios except for intra-satellite handover with the same feeder link, the source cell can not determine the N\_TA for target cell and provide it to UE, so NTN RACH-less HO is not supported in these scenarios. |
| Thales | Yes |  |
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## High-level procedure

As RAN2 has agreed LTE RACH-less HO is the baseline, and both pre-allocated and dynamic grant for initial UL transmission are supported. It would be good to first confirm the high-level procedure for NTN RACH-less HO and then further fill in detailed procedures, identify and resolve NTN-specific issues, etc.. The following high-level UE procedure is proposed. Note RACH-less HO failure is not included here, which can be further discussed.

**Q2) Do you agree the procedure for NTN RACH-less HO as follows?**

1. **receive a RACH-less HO command which can include N\_TA, preallocated grant.**
2. **start timer T304**
3. **perform DL and UL synchronization, and start timer T430**
4. **start time alignment timer**
5. **monitor PDCCH for dynamic grant if pre-allocated grant is not configured in RACH-less HO command**
6. **send initial UL transmission including RRCReconfigurationComplete message using the available UL grant**
7. **consider RACH-less HO is completed upon receiving NW confirmation**
8. **stop timer T304 and release UL grant for initial UL transmission**

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| **Company** | **Yes/No** | **Comments** |
| Samsung | Yes |  |
| CMCC | See comments | Step1 is not applicable to NTN UE, since NTN UE could derive the TA value based on ephemeris of target satellite and its own location. In addition, step 2-8 may not be mandatory considering PCI unchanged solution. |
| CATT | Yes with comments | In current procedure, it is unclear which layer, e.g. MAC or RRC, performs the corresponding behavior. So, we are wondering whether the behaviours can be categrated into layers. |
| vivo | See comments | We agree the general procedure above except for the description of N\_TA in step-1. Except for intra-satellite handover with the same feeder link, the source cell can not determine the N\_TA for target cell, so we think rach-less HO is only supported for intra-satellite handover with the same feeder link. For such a scenario, N\_TA in the target cell is identical to the source cell and does not need to be included in rach-less HO command. |
| Thales | Yes | Same comment as CATT concerning layers clarification |
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How to confirm RACH-less HO successful completion needs to be discussed. In LTE “UE Contention Resolution Identity MAC CE” is used to confirm RACH-less handover is successfully completed. When UE receives this MAC CE in target cell, it stops T304. Since there is no contention during RACH-less, the MAC CE body is ignored by UE, which means only the MAC CE subheader (i.e., the LCID) is actually used for this purpose. The intention is to confirm the RRCReconfigurationComplete message is received by target cell successfully. Compared to LTE RACH-less approach, other solutions can also be considered to be more efficient, e.g., the reception of PDCCH addressed to C-RNTI after the initial UL transmission.

**Q3) Which option(s) do you agree for the confirmation of RACH-less HO completion?**

**Option 1: reuse of LTE approach, i.e., UE Contention Resolution Identity MAC CE is used but UE ignores the content of this field.**

**Option 2: the reception of PDCCH addressed to the UE’s C-RNTI in target cell.**

**Option 3: the reception of UE’s C-RNTI MAC CE.**

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| **Company** | **Option(s)** | **Comments** |
| Samsung | 2 |  |
| CMCC | 1 | In LTE, option 1 has experienced a long discussion time, no need to repeat. |
| CATT | 1 | Actually, Option 1 follows the mechanism in LTE which is definitely agreeable.  Current Option 2 may not work. When the uplink grant is scheduled by PDCCH, there may be some issues. For example, the UE performs the initial transmission in the first UL grant scheduled by the PDCCH. It may happen that the network does not detect this transmission, due to poor channel condtion or uplink synchoronization issue. And the network may send the PDCCH again. From the UE’s perspective, the UE will consider this is the confirmation according to option 2. But from the network’s perspective, it still wait for the UE’s uplink transmission. This misunderstanding brings transmission failure eventually. Hence, we suggest one revision for option 2 as following:  **Option 2a: the reception of PDCCH addressed to the UE’s C-RNTI in target cell *indicating successful initial UL transmission, e.g. PDCCH inidicating one new transmission for UL and DL***.  For option 3, we think this brings new DL MAC CE, which is not necessary. |
| vivo | Option 1 |  |
| Thales | Option 1 |  |
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## Initial UL transmission

In LTE, the terminology “preallocated” grant is used specifically for RACH-less HO. If preallocated grant is provided in RRC RACH-less HO command, UE directly uses it and sends initial UL transmission to the target cell. In NR, configured grant (CG) is used for UL transmission without dynamic grant (DG) by PDCCH, which can be used as a baseline for the preallocated grant and to be further optimized/tailored.

The configured grant works in two schemes: for type-1 CG the actual grant for UL transmission is configured via RRC, for type-2 CG the actual grant for UL transmission is provided/activated via PDCCH. For NTN RACH-less HO, considering the long propagation delay and potential initial UL transmission storm, which scheme is used for the initial UL transmission can be discussed. For type-1, the preallocated grant can be directly used for initial UL transmission after RACH-less HO command is received, similar to type-1 CG, so there is no delay in waiting for UL grant but it may cause potential initial UL transmission storm. For type-2, the preallocated grant can be configured in RRC and activated by PDCCH, similar to type-2 CG, so delay in waiting for UL grant activation is expected but NW can more control to distribute initial UL transmissions from UEs and mitigate potential storm.

**Q4) Which option(s) do you agree for the preallocated grant?**

**Option 1: the preallocated grant is provided as type-1 CG**

**Option 2: the preallocated grant is provided as type-2 CG**

**Option 3: support both Option 1 and Option 2, but only one is configured**

**Option 4: Option 1 and Option 2 can be configured together**

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| **Company** | **Option(s)** | **Comments** |
| Samsung | 1 or 3 | Option 1 is more aligned with LTE preallocated grant. Option 3 allows more flexibility. |
| CMCC | 1 | Reuse LTE mechanism. |
| CATT | 1 | Optino 2 requires PDCCH activation which brings extra latency to the whole procedure.  Option 3/4 include option 2. |
| vivo | Option 1 or option 3 |  |
| Thales | 1 | Reuse LTE solution. |
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Since NTN is deployed in NR where multi-beam operation is supported, UE can select a suitable beam for UL transmission. In RACH based HO, a suitable beam (SSB/CSI-RS) is first selelcted based on a configured RSRP threshold and then the PRACH resource corresponding to the selected beam is determined. The initial UL transmission in CG-SDT can also be considered as a reference. For CG-SDT, type-1 CG is configured, a SSB is selected based on a configured RSRP threshold and the corresponding configured grant is used for initial UL transmission. Similarly, the preallocated grant can be provided with association to SSBs, and SSB selection based on a configured RSRP is performed for initial UL transmission.

**Q5) Do you agree that the preallocated grant is provided with association to SSBs?**

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| **Company** | **Yes/No** | **Comments** |
| Samsung | Yes |  |
| CMCC | FFS | In NR NTN, multiple beams operation has not been discussed in both RAN1 and RAN2, therefore we prefer to wait for RAN1 input. |
| CATT | Comments | We agree with CMCC that this is in RAN1 scope. But in CG-SDT, the solution mapping SSB and CG resources has been agreed. We think it can be considered as reference.  CG-SDT-Configuration-r17 ::= SEQUENCE {  cg-SDT-RetransmissionTimer INTEGER (1..64) OPTIONAL, -- Need R  sdt-SSB-Subset-r17 CHOICE {  shortBitmap-r17 BIT STRING (SIZE (4)),  mediumBitmap-r17 BIT STRING (SIZE (8)),  longBitmap-r17 BIT STRING (SIZE (64))  } OPTIONAL, -- Need S  sdt-SSB-PerCG-PUSCH-r17 ENUMERATED {oneEighth, oneFourth, half, one, two, four, eight, sixteen} OPTIONAL, -- Need M  sdt-P0-PUSCH-r17 INTEGER (-16..15) OPTIONAL, -- Need M  sdt-Alpha-r17 ENUMERATED {alpha0, alpha04, alpha05, alpha06, alpha07, alpha08, alpha09, alpha1} OPTIONAL, -- Need M  sdt-DMRS-Ports-r17 CHOICE {  dmrsType1-r17 BIT STRING (SIZE (8)),  dmrsType2-r17 BIT STRING (SIZE (12))  } OPTIONAL, -- Need M  sdt-NrofDMRS-Sequences-r17 INTEGER (1..2) OPTIONAL -- Need M  } |
| vivo | Yes with comments | The final decision requires RAN1 input. |
| Thales | Yes but | Wait for RAN1 input. |
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**Q6) If yes to Q4, do you agree a RSRP threshold is configured for SSB selection for preallocated grant?**

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| **Company** | **Yes/No** | **Comments** |
| Samsung | Yes |  |
| CMCC | Pls. see our comment to Q5 |  |
| CATT | Comments | See Q5) |
| vivo | Yes with comments | The existing mechanism of SSB selection can be the baseline. But the final decision still requires RAN1 input. |
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Furthermore, several issues on initial UL transmission may involve RAN1. Considering RAN1 has no TU on NTN HO enhancement, relevant discussion can be first triggered in RAN2 to collect views and potential solutions.

One issue is about PDCCH monitoring for dynamic grant. To receive dynamic grant, UE monitors PDCCH in the target cell. Different from RACH-based handover where UE monitors PDCCH using the selected beam during the RACH procedure (i.e. the selected SSB beam for RO/preamble mapping and RAR reception), there is no RACH procedure for RACH-less handover. Hence, how to monitoring PDCCH to receive dynamic grant for the initial UL transmission needs to be considered. One possible solution is that network indicates suitable SSB beams (TCI states) in RACH-less HO command for UE to monitor PDCCH in the target cell. This can be done by the target cell as it can have beam measurement results forwarded by the source cell.

**Q7) Do you agree that from RAN2 perspective beam indication can be provided in RACH-less HO command for UE to monitor PDCCH?**

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| **Company** | **Yes/No** | **Comments** |
| Samsung | Yes |  |
| CMCC | Pls. see our comment to Q5 |  |
| CATT | Comments | See Q5) |
| vivo | No | Similar to RACH-based HO, it is more reasonable for the UE to select the beam itself than for the network to indicate the beam. |
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Another issue is about power control. For initial UL transmission by dynamic grant, assuming DCI can indicates power control parameters, UE follows the indicated parameters to adjust the transmission power. For initial UL transmission using preallocated grant, the first option to be consider is to follow LTE principle, where the power control follows the rules specified for PUSCH scheduled by Random access grant. Another option, considering the pre-allocated grant can be seen as a special type of configured-grant, is to consider the power control mechanism used for PUSCH scheduled by configured grant.

**Q8) Do you agree for power control of initial UL transmission using preallocated grant** **following options can be considered from RAN2 perspective? Which option is preferred?**

**Option 1: Follow the power control rule applied for PUSCH scheduled by RAR**

**Option 2: Follow the power control rule applied for PUSCH scheduled by configured grant**

**Option 3: others**

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| **Company** | **Option(s)** | **Comments (e.g., other solution)** |
| CATT | Others | We think this can follow LTE but this is in RAN1 scope. |
| vivo | See comments | The discussion of power control is in RAN1 scope, we should ask RAN1 regarding this issue. |
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A LS needs be sent to RAN1 to inform RAN2 agreements on NTN RACH-less HO and check views on relevant issues/solutions (e.g., PDCCH monitoring for DG, power control, etc).

**Q9) Do you agree that RAN2 sends a LS to RAN1 on NTN RACH-less HO to inform RAN2 agreements and check RAN1 views on PDCCH monitoring and power control, e.g., the potential solutions discussed in Q7 and Q8, and other issues if any?**

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| **Company** | **Yes/No** | **Comments (e.g., any other aspects)** |
| CATT | Yes | We think the mapping betweem SSB and pre-allocated UL grant can also be included in the LS. |
| vivo | Yes | Potential solutions discussed in Q5 and Q6 need to be confirmed by RAN1. |
| Thales | Yes | Include Q5 and Q6 in the LS. |
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## Interaction between RACH-less and CHO

The combination of RACH-less HO and CHO is proposed to obtain the benefits of both. The feasibility needs to be checked first. Since the CHO execution timing is unknown, how long the preallocated grant is valid and when to send dynamic grant in PDCCH are questionable. Given the time information is available for when and how long the target cell has to reserve the RACH-less resources, time-based CHO with RACH-less handover can be possible. Another question is whether the configured N\_TA can be considered valid at CHO execution timing.

**Q10) For the combination of RACH-less HO and CHO, please comment how and in which conditions this would work, considering conditions on N\_TA, time-based event (condEventT1), preallocated grant, dynamic grant, etc.**

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| **Company** | **Comments** |
| CATT | For NTN, since the trajectory of the satellite can be predicated, we think the time when the UL grant is valid in the target cell can also be predicated. This implies CHO combing RACH-less is feasible. |
| vivo | If rach-less HO and CHO combine, the configuration (e.g., preallocated grant) will not be suitable when the condition of CHO is fulfilled or the grant resources will be greatly wasted since the NW doesn't know when UE performs HO. To address such an issue, a lot of discussions may be needed. This topic can be de-prioritized considering there is not much time left for this release. |
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# Conclusions

**For agreement:**

**For discussion:**

# References

1. [R2-2303734](file:///C:\Data\3GPP\Extracts\R2-2303734%20-%20Handover%20enhancements.docx) Handover enhancements Ericsson discussion Rel-18 NR\_NTN\_enh
2. [R2-2303768](file:///C:\Data\3GPP\Extracts\R2-2303768.docx) Discussion on NTN handover enhancements Samsung Research America discussion Rel-18 NR\_NTN\_enh-Core
3. [R2-2302545](file:///C:\Data\3GPP\Extracts\R2-2302545%20NTN%20connected%20mode%20mobility.doc) Discussion on NTN handover enhancements OPPO discussion Rel-18 NR\_NTN\_enh-Core
4. [R2-2302564](file:///C:\Data\3GPP\Extracts\R2-2302564.docx) Discussion on NTN HO Enhancements CATT discussion Rel-18 NR\_NTN\_enh-Core
5. [R2-2302698](file:///C:\Data\3GPP\Extracts\R2-2302698%20Discussion-on-NTN-RACH-less-handover.docx) Discussion on NTN RACH-less handover Intel Corporation discussion Rel-18 NR\_NTN\_enh-Core
6. [R2-2303038](file:///C:\Data\3GPP\Extracts\R2-2303038%20RACH-less%20HO.doc) RACH-less handover for NTN Qualcomm Incorporated discussion Rel-18 NR\_NTN\_enh-Core
7. [R2-2303099](file:///C:\Data\3GPP\Extracts\R2-2303099%20Discussion%20on%20NTN%20handover%20enhancements.docx) Discussion on NTN handover enhancements Huawei, HiSilicon, Turkcell discussion Rel-18 NR\_NTN\_enh
8. [R2-2303141](file:///C:\Data\3GPP\Extracts\R2-2303141%20Consideration%20on%20HO%20enhancements%20in%20NTN.docx) Consideration on HO enhancements in NTN ZTE Corporation, Sanechips discussion Rel-18
9. [R2-2303142](file:///C:\Data\3GPP\Extracts\R2-2303142%20Consideration%20on%20RACH-less%20HO%20in%20NTN.docx) Consideration on RACH-less HO in NTN ZTE Corporation, Sanechips discussion Rel-18
10. [R2-2303170](file:///C:\Data\3GPP\Extracts\R2-2303170%20Even%20Further%20Aspects%20on%20Connected-mode%20Mobility%20in%20Rel-18%20NTN.docx) Even Further Aspects on Connected-mode Mobility in Rel-18 NTN Nokia, Nokia Shanghai Bell discussion Rel-18 NR\_NTN\_enh-Core
11. [R2-2303256](file:///C:\Data\3GPP\Extracts\R2-2303256%20Considerations%20on%20supporting%20RACH-less%20HO%20in%20NTN.docx) Considerations on supporting RACH-less HO in NTN Lenovo discussion Rel-18
12. [R2-2303332](file:///C:\Data\3GPP\Extracts\R2-2303332%20Support%20RACH-less%20HO%20and%20CHO.docx) Support RACH-less HO and CHO NEC discussion Rel-18 NR\_NTN\_enh-Core
13. [R2-2303418](file:///C:\Data\3GPP\Extracts\R2-2303418_NTN%20specific%20handover%20enhancement_v0.doc) NTN specific handover enhancement Apple discussion Rel-18 NR\_NTN\_enh-Core
14. [R2-2303441](file:///C:\Data\3GPP\Extracts\R2-2303441%20Discussion%20on%20handover%20enhancements%20for%20NTN-NTN%20mobility.doc) Discussion on handover enhancements for NTN-NTN mobility Xiaomi discussion
15. [R2-2303526](file:///C:\Data\3GPP\Extracts\R2-2303526%20Discussion%20on%20common%20(C)HO%20configuration,%20RACH-less%20HO%20and%20group%20HO%20for%20NTN.docx) Discussion on common (C)HO configuration, RACH-less HO and group HO for NTN CMCC discussion Rel-18 NR\_NTN\_enh-Core
16. [R2-2303932](file:///C:\Data\3GPP\Extracts\R2-2303932%20Discussion%20on%20RACH-less%20handover%20for%20NTN.docx) Discussion on RACH-less handover for NTN ASUSTeK discussion Rel-18 NR\_NTN\_enh-Core
17. [R2-2303977](file:///C:\Data\3GPP\Extracts\R2-2303977%20%5bNTN%5d%20Discussion%20on%20handover%20enhancements.docx) Discussion on handover enhancements LG Electronics France discussion Rel-18 NR\_NTN\_enh-Core