**3GPP T****SG-RAN WG2 Meeting #117-e R2-2203568**

**E-Meeting, Feb 21th – Mar 3rd, 2022**

**Agenda item:**  **8.10.4.1**

**Source: Intel Corporation**

**Title: Report of email discussion [AT117-e][104][NTN] UE caps open issues (Intel) 3rd round**

**Document for: Discussion**

# Introduction

This is the report of the following email discussion:

* [AT117-e][104][NTN] UE caps open issues (Intel)

Initial scope: Discuss UE caps open issues based on the report in [R2-2202454](file:///C:\Data\3GPP\Extracts\R2-2202454%20Report%20of%20email%20discussion%20%5bPre117-e%5d%5b104%5d%5bNTN%5d%20UE%20caps%20open%20issues%20(Intel).docx) and other company contributions in AI 8.10.4

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): Monday 2022-02-21 1700 UTC

Initial deadline (for rapporteur's summary in R2-2203535): Monday 2022-02-21 2000 UTC

Updated scope:

1. Continue the discussion on UE caps open issues
2. Update the 38.306 and 38.331 CRs

Updated 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)
    - Updated 38.306 and 38.331 CRs

Updated deadline (for companies' feedback): Thursday 2022-02-24 1400 UTC

Updated deadline (for rapporteur's summary in R2-2203546): Thursday 2022-02-24 1600 UTC

Deadline (for CRs in R2-2203550 and R2-2203551): Thursday 2022-03-03 1000 UTC

Updated scope:

1. Continue the discussion on idle mode open issues
2. Update the 38.306 and 38.331 CRs

Updated 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)
    - Updated 38.306 and 38.331 CRs

Updated deadline (for companies' feedback): Monday 2022-02-28 1600 UTC

Updated deadline (for rapporteur's summary in R2-2203568): Monday 2022-02-28 1800 UTC

Deadline (for CRs in R2-2203550 and R2-2203551): Thursday 2022-03-03 1000 UTC

Proposals marked "for agreement" in R2-2203568 not challenged until Tuesday 2022-03-01 1000 UTC will be declared as agreed via email by the session chair (for the rest the discussion will continue online).

# Discussion

## First round

According to the pre-meeting discussion on UE capabilities [1], the following proposals are made for easy agreements:

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| ** List of proposals for agreement:**  **Proposal 1: The SMTC enhancements (event-triggered assistance information reporting, 2 SMTC in parallel) are essential for NGSO capable UEs.**  **Proposal 4: Incorporate event-triggered TA reporting feature into TA reporting UE capability defined in RAN1 feature list.**  **Proposal 5: Specify single UE capability to represent the support of both UL HARQ state B and the new LCP restriction.**  **Proposal 6: Since it should not be assumed that every NTN capable UE has been tested to support both GSO and NGSO, define IoT bits for the support of {GSO, NGSO, both}.**  **Proposal 9: Add a note in 38.306 that for NTN NW restricts throughput based on the actual RTT to avoid buffer overflow.** |

This short at-meeting offline is supposed to make some progress even before the online discussion, as mentioned by session chair “Note that especially for the NR NTN offlines the deadlines are quite short, but the main intention for this initial round is basically to attempt email agreements for some of the proposals that were prepared as an outcome of the corresponding Pre117 discussions (needless to say, I encourage companies to be reasonable and accept as many as possible already in this initial round).”.

**Question 1: Whether the following proposals can be agreeable?**

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| ** List of proposals for agreement:**  **Proposal 1: The SMTC enhancements (event-triggered assistance information reporting, 2 SMTC in parallel) are essential for NGSO capable UEs.**  **Proposal 4: Incorporate event-triggered TA reporting feature into TA reporting UE capability defined in RAN1 feature list.**  **Proposal 5: Specify single UE capability to represent the support of both UL HARQ state B and the new LCP restriction.**  **Proposal 6: Since it should not be assumed that every NTN capable UE has been tested to support both GSO and NGSO, define** **IoT bits for the support of {GSO, NGSO, both}.**  **Proposal 9: Add a note in 38.306 that for NTN NW restricts throughput based on the actual RTT to avoid buffer overflow.** |

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| **Company** | **Y or N** | **Additional comments** |
| Huawei, HiSilion | Y | Regarding P4, we still think “TA reporting during initial access” should be optional without capability because the NW does not know UE capability yet during initial access, so the RAN1 capability should refer only to “TA reporting in Connected mode” (this is not the intention of RAN1, so they should be informed). But we can accept P4 if the majority of companies prefer it. |
| ZTE | Y |  |
| Nokia | Partly Y | On P6: will that in practice mean that there is no mandatory set of NTN capabilities which all UEs support (no matter if they operate in NGSO or GSO), but each time there will be a need to indicate with IoT bit?  On P9: we think such note is not essential. |
| Lenovo, Motorola Mobility | Y |  |
| MediaTek | Y |  |
| OPPO | Y |  |
| Xiaomi | Y |  |
| Samsung | Y |  |
| Qualcomm | Comments for P6  N for P9  Y for others. | On P6, it is not clear if this is indication is only for the essential features or for whole container.  P9: we agree with Nokia. What network behaviour is does not need to be captured in the specification. |
| vivo | Y |  |
| Ericsson | Partly  P6: N  P9: N | On P6: we think this may greatly increase the number of UE capabilities and that it is better to clarify for each feature the technical limits, especially all legacy features shall not need GSO/NGSO/both indications.  On P9: not needed. |
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**Summary:**

Companies are fine with the following proposals:

**Proposal 1: The SMTC enhancements (event-triggered assistance information reporting, 2 SMTC in parallel) are essential for NGSO capable UEs.**

**Proposal 4: Incorporate event-triggered TA reporting feature into TA reporting UE capability defined in RAN1 feature list.**

**Proposal 5: Specify single UE capability to represent the support of both UL HARQ state B and the new LCP restriction.**

For P6, the concerns are whether it “means that there is no mandatory set of NTN capabilities which all UEs support”, and “if this indication is only for the essential features or for whole container”.

Regarding the first concern, as RAN2 has agreed that “define one single NR NTN UE capability to encompass essential features to support NTN”, there is still “mandatory set of NTN capabilities”. But with this newly introduced IoT bits, they are actually like “mandatory with capability signalling”, which means although UE is mandatory to support this “mandatory set of NTN capabilities”, there are still IoT bits to show whether the UE has been tested in the corresponding scenario.

As for the second concern, since these IoT bits are specific for application scenarios, they are supposed to cover all essential and optional UE capabilities. And rapporteur suggests to further revise P6 as below

**Proposal 6: Since it should not be assumed that every NTN capable UE has been tested to support both GSO and NGSO, define IoT bits for the support of {GSO, NGSO, both} and this indication means all NTN essential features and optional features UE indicates have been tested in the corresponding scenario(s).**

For P9, it seems the concern is whether a Note is needed, rapporteur suggests to add an FFS for this part. And P9 can be revised like the agreement made in IoT NTN as follows:

**Proposal 9: For NTN, network may need to restrict data throughput based on the actual RTT to avoid UE buffer overflow. FFS if a note in 38.306 is needed.**

According to [2], the following open issues are identified to be postponed due to lack of stage-3 detail or input from other WGs:

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| **List of open issues on NR NTN UE capabilities**  **Set 2 for postponed open issues:**  **Postponed discussion (need to wait for other WG’s input or more stage-3 discussion):**   1. Postpone the discussion on granularity of SMTC UE capabilities (e.g., 4 SMTC in parallel), since RAN1/4 may define them as per band 2. Postpone the UE capability discussion on measurement gaps for connected mode; 3. Postpone the UE capability discussion on location reporting. |

The following proposals from companies’ papers are related to the open issues above:

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| proposals from [3]:  **Proposal 1 Multiple measurement gap patterns is an essential capability for NGSO.**  **Proposal 2 No separate capability is introduced for measurement gaps for connected mode.**  **Proposal 3 Location reporting should be a mandatory capability.**  proposal from [4]:  **Proposal 1: it is proposed to specify the SMTC enhancement with 4 SMTC configurations in parallel as optional sub-features, and can be** **revisited based on RAN4/RAN1’s further input.**  **Proposal 2: it is proposed that this capability is per band, not per UE.**  **Proposal 3: it is proposed to specify the extended GAP length and/or the number of multiple GAPs as optional sub-features, and the detailed number and length can be specified based on RAN4/RAN1’s input.**  proposal from [6]:  **Proposal 4: An optional UE capability should be added to indicate the support of multiple NTN measurement gaps for NGSO.** |

Regarding gap enhancements, it’s still not clear about the stage-3 detail. And for location reporting, RAN2 is still waiting for other WGs’ reply. With respect to 4 SMTCs in parallel, we can try if some consensus can be made for now.

**Question 2: Regarding 4 SMTCs in parallel, which option can be adopted:**

**Option 1: Postpone the discussion until RAN1/4 input is received;**

**Option 2: Define per-band optional UE capability for 4 SMTCs in parallel, and revisit it based on RAN4/RAN1’s further input.**

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| **Company** | **option 1 or 2** | **Additional comments** |
| Huawei, HiSilion | Option 1 |  |
| ZTE | Option 1 |  |
| Nokia | Option 1 | It is OK to wait for one more meeting, UE capabilities can be finalized after we freeze the functional specification. |
| Lenovo, Motorola Mobility | Option 1 |  |
| MediaTek | Option 1 |  |
| OPPO | Option 1 |  |
| Xiaomi | Option 1 |  |
| Samsung | Option 1 |  |
| Qualcomm | Option 2 | If we go with option 1, then we suggest sending LS to RAN4 otherwise RAN4 may not discuss or provide any feedback on this. |
| vivo | Option 1 | UE capability discussion is not in urgency anyway. |
| Ericsson | Option 1 |  |
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**Summary:**

The majority view is to wait for RAN1/4 further input. And one company also raises a point that a LS is needed otherwise “RAN4 may not discuss or provide any feedback on this”. Since current plan is RAN1 and RAN4 provide the updated feature list by the end of first meeting week. Rapporteur suggests to make the following proposal:

**Proposal 10:** **Postpone the discussion on NTN SMTC UE capabilities, and if the updated RAN1/4 feature lists during this meeting don’t include NTN SMTC related UE capabilities, RAN2 sends an LS to RAN1/4 for triggering this discussion.**

One proposal in [6] raises another UE capability for HARQ process number as below:

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| Apart from the discussion on measurement gaps, we think it is also useful to add a UE capability for the supported number of HARQ processes. In the current spec, the UE supports 16 UL/DL HARQ processes. For NTN, RAN1 has introduced a UE feature of supporting 32 HARQ processes, with an optional capability [2]. The main motivation is to avoid HARQ stalling due to the large RTD. Moreover, in NTN, some HARQ processes can be retransmitted (state A) and others can be configured as no-retransmission (state B).  From our perspective, it is beneficial for UEs to report its maximum number of HARQ processes to be retransmitted. For instance, a UE can report it supports a maximum of 16 HARQ processes of state A, then the NW can configure 16 HARQ processes of state A and 16 HARQ processes of state B, and the 16 state B processes can share a common buffer. If not reported, the NW could configure all 32 HARQ processes as state A, which may exceed the UE competence.  **Proposal 5: Introduce an optional capability for the maximum number of HARQ processes to be retransmitted.** |

**Question 3: Whether** **to have separate UE capability to indicate maximum number of state A HARQ processes?**

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| **Company** | **Y or N** | **Additional comments** |
| Huawei, HiSilicon | Y | Proponent. |
| Nokia | N | We see no critical need for this separate UE capability. In our understanding this 32 should not be split statically into A and B. So it is up to NW how to use it and UE does not need to signal any additional capability. |
| MediaTek | N |  |
| OPPO | N | Optionally indicating the support of 32 HARQ processes is sufficient. |
| Xiaomi | N |  |
| Samsung | N | We think it’s fine to rely on NW configuration. |
| Qualcomm | N |  |
| vivo | N | We think the RAN1-introduced maximum supported HARQ process is already enough. |
| Ericsson | N |  |
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**Summary:**

As the majority view is not to have separate UE capability to indicate maximum number of state A HARQ processes, no proposal is made in this aspect.

In [1] the following proposal is made for SMTC enhancements applied in GSO.

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| **Proposal 2: RAN2 to further discuss whether the SMTC enhancements (event-triggered assistance information reporting, 2 SMTC in parallel) are also essential for GSO capable UEs, considering except GEO satellites in general other GSO satellites are also moving.** |

According to the observations in [5] as below, UE can also benefit from SMTC enhancements in GSO case.

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| **Observation 1: For a short time, e.g. several minutes, GSO satellites could be considered as “stationary”. But for a long time, e.g. several hours, the movement of GSO cannot be ignored.**  **Observation 2: In GSO scenario, one UE may be served by a bunch of satellites one by one, or one UE may be in the overlap area of several GSO satellites, which requires multiple SMTCs to track different neighbour cells.** |

**Question 4: Whether the SMTC enhancements (event-triggered assistance information reporting, 2 SMTC in parallel) are also essential for GSO capable UEs?**

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| **Company** | **Y or N** | **Additional comments** |
| Huawei, HiSilicon | N | Agree that the SMTC enhancements can be used for GSO as well (mainly for GSO-NGSO mobility), but we think it can be an optional capability since it is unclear for the moment whether GSO-NGSO mobility is common in real deployment. |
| ZTE | Y |  |
| Nokia | Y | We think event-triggered assistance info and 2 SMTCs in parallel should be mandatory for all NTN UEs (not only NGSO). |
| Lenovo, Motorola Mobility | Y |  |
| MediaTek | N |  |
| OPPO | N | Agree with Huawei |
| Xiaomi | N |  |
| Samsung | N |  |
| Qualcomm | Y/N | As we mentioned before, it may be better first to clarify whether GSO to NGSO mobility needs to be supported. It can be conditional based on GSO to NGSO mobility support. |
| vivo | Y | We can follow the majority’s view. |
| Ericsson | N | Even in the case of multiple GSO satellites overlapping, the movement can be ignored only for long periods of time. In this case, a validity timer would suffice (R2-2202564). |
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**Summary:**

There is still no consensus on whether the SMTC enhancements (event-triggered assistance information reporting, 2 SMTC in parallel) are also essential for GSO. And one company thinks RAN2 also needs to discuss whether mobility between GSO and NGSO is supported. Taking the IoT bits for scenarios into account, rapporteur suggest to add a new proposal for further discussion.

**Proposal 11: RAN2 to discuss whether** **IoT bit for the support of {both GSO and NGSO} means UE also supports mobility between GSO and NGSO.**

In [1] the following controversial open issues are suggested to go for online discussion:

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| **(10/14) Proposal 3: CHO enhancements (time based and Event A4 based CHO) are optional to support for NTN capable UEs.**  **Proposal 7: RAN2 to discuss whether we plan to check case by case if a TN optional UE capability needs a separate IoT bit for NTN.**  **Proposal 8: If there is no plan to check case by case, RAN2 to further discuss how to support separate UE capability reporting for TN and NTN:**  **Option 1**: IoT bits for NTN are reported together with TN features, e.g., have an embedded ASN.1 structure as below:  UE-NR-Capability ::= SEQUENCE {  <Unnecessary parts omitted>  iotBitsNTN UE-NR-Capability OPTIONAL,  <Unnecessary parts omitted>  }  **Option 2**: Existing capability signalling is used but only valid in the network type it is reported to (e.g. when UE reports to NTN network the capability refers to NTN and not TN).  **Option 3**: Add nr-ntn as a new RAT-type for UE capability reporting, in this case NTN source gNB can get UE TN capabilities to support handover preparation from NTN to TN. |

Since we may not have enough time during this very short first round, rapporteur still suggests to go for online discussion or second round at-meeting offline.

## Second round

In the second round of the offline discussion, we further discuss the following remaining issues on UE capabilities.

**SMTC:**

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| **Proposal 2: RAN2 to further discuss whether the SMTC enhancements (event-triggered assistance information reporting, 2 SMTC in parallel) are also essential for GSO capable UEs, considering except GEO satellites in general other GSO satellites are also moving.** |

Since this proposal has been discussed in the first round and the situation is still 50:50, also considering one agreement was made to postpone the discussion on NTN SMTC UE capabilities, we can revisit this issue after the updated RAN1/4 feature list including NTN SMTC related UE capabilities is received.

**CHO:**

This issue has been discussed in pre-meeting offline [1], and the discussion summary is as below:

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| **Question 2: Whether CHO enhancements (time based and Event A4 based CHO) are essential for both GSO and NGSO, or only for NGSO, or optional.?**   |  |  |  | | --- | --- | --- | | **Company** | **Essential for which case(s), or optional** | **Additional comments** | | InterDigital | Essential for NGSO | Similar to Q1 can have a capability that is optional for GSO and mandatory for NGSO | | MediaTek | Only for NGSO | Similar to Q1 | | Samsung | Optional | As CHO is optional in Rel-16. | | Qualcomm | Optional | How this can work correctly for NGSO moving cell as the network may not have accurate UE location information.  As Samsung indicated, it is already optional in Rel-16 and we will be using same Rel-16 per band UE capability indication in NTN. | | Apple | Optional |  | | Huawei, HiSilicon | Optional | We think time-based CHO is useful for NGSO (not for GSO). If neither time-based nor location-based CHO is supported by the UE, the overall performance will be degraded as the legacy RSRP-based mobility does not work well in NTN.  However, if companies have concerns, we are also ok with having it as an optional feature since the UE can implement optional features anyway. | | Lenovo, Motorola Mobility | Optional | As legacy CHO in Rel-16. | | OPPO | Optional |  | | Xiaomi | Optional |  | | vivo | Optional | Same view as Samsung | | Spreadtrum | Optional |  | | Nokia | Essential for NGSO | Can be optional for GSO. | | Thales | Essential for NGSO | Especially for quasi Earth fixed beam scenarios and possibly for Earth moving beam scenario | | Intel | Optional |  | |  |  |  |   **Summary:**  4 companies think CHO enhancements (time based and Event A4 based CHO) are essential for NGSO, while other 10 companies think it could be optional. So the majority view is to let UE decide whether to support CHO related enhancements for NTN, and don’t specify a mandatory requirement.  **(10/14) Proposal 3: CHO enhancements (time based and Event A4 based CHO) are optional to support for NTN capable UEs.** |

We could make one more try in this offline to see if this proposal is agreeable.

**Question 5: Whether the following proposal is agreeable?**

**Proposal: CHO enhancements (time based and Event A4 based CHO) are optional to support for NTN capable UEs.**

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| **Company** | **Y or N** | **Additional comments** |
| Thales | No | It should be essential especially for quasi Earth fixed cell scenario |
| Qualcomm | Yes | CHO procedure is not only about time, it is on the top of whole end to end Rel-16 CHO functionality. |
| Apple | Yes | Same view as Qualcomm. |
| Huawei, HiSilicon | Yes |  |
| Samsung | Yes |  |
| OPPO | Yes |  |
| vivo | Yes |  |
| Xiaomi | Yes |  |
| NEC | Yes | We prefer to have this feature mandatory for better performance, but at this stage we can compromise to majority view to have it optional |
| Nokia | No | We think it is essential for NGSO UEs. |
| Ericsson | N | We think CHO is essential for quasi earth fixed cells of NGSO. However, in the interest of progress we can accept optional with capability signalling if that is the majority view. |
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**Summary:**

The clear majority view is to consider CHO enhancements (time based and Event A4 based CHO) as optional UE capabilities, and not to specify a mandatory requirement. One company support “essential for NGSO” can also accept optional with capability signalling.

**Proposal 1: the UE capabilities for time based CHO and Event A4 based CHO are optional with capability signalling.**

**IoT bits for existing TN UE capabilities**

An initial online discussion has been done for collecting companies’ views, the minutes are as below:

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| Proposal 7: RAN2 to discuss whether we plan to check case by case if a TN optional UE capability needs a separate IoT bit for NTN.  Proposal 8: If there is no plan to check case by case, RAN2 to further discuss how to support separate UE capability reporting for TN and NTN:  Option 1: IoT bits for NTN are reported together with TN features, e.g., have an embedded ASN.1 structure as below:  UE-NR-Capability ::= SEQUENCE {  <Unnecessary parts omitted>  iotBitsNTN UE-NR-Capability OPTIONAL,  <Unnecessary parts omitted>  }  Option 2: Existing capability signalling is used but only valid in the network type it is reported to (e.g. when UE reports to NTN network the capability refers to NTN and not TN).  Option 3: Add nr-ntn as a new RAT-type for UE capability reporting, in this case NTN source gNB can get UE TN capabilities to support handover preparation from NTN to TN.   * Huawei thinks we could go for a case by case check. Samsung agrees * Oppo thinks option2 would not work (VC tends to agree) and option 1 would be the best and less time consuming * QC assume that option 1 is only for "per-UE" capabilities and is then the simplest |

Currently there are four options on the table, i.e., case by case option in P7(option 0) and three options in P8 (option 1/2/3). In order to have a clear understanding on these options, they are elaborated as below:

**Option 0**: We need to identify which existing capabilities should have IoT bits for NTN, and for other UE capabilities when UE indicates it, it means this UE capability is supported in both TN and NTN. For example, if RAN2 defines a NTN IoT bit for 2-step RACH, it means when UE indicates *twoStepRACH-r16* (existing capability bit) it’s only for the support of 2-step RACH in TN, and when UE indicates *twoStepRACHNTN-r16* (new IoT bit), it’s for the support of 2-step RACH in NTN. Meanwhile, if RAN2 doesn’t define a NTN IoT bit for inactive state, when UE indicates *inactiveState* (existing capability bit), it means UE support inactive state in both TN and NTN.

**Option 1**: IoT bits for NTN are reported together with TN features, e.g., have an embedded ASN.1 structure as below:

UE-NR-Capability ::= SEQUENCE {

<Unnecessary parts omitted>

iotBitsNTN UE-NR-Capability OPTIONAL,

<Unnecessary parts omitted>

}

In this way, it enables all signalling possibilities to accommodate all UE capabilities. Also as suggested by Qualcomm, only per-UE capabilities are needed to indicate.

**Option 2**: Existing capability signalling is used but only valid in the network type it is reported to (e.g. when UE reports to NTN network the capability refers to NTN and not TN).

**Option 3**: Add nr-ntn as a new RAT-type for UE capability reporting, in this case NTN source gNB can get UE TN capabilities to support handover preparation from NTN to TN. It means UE reports TN and NTN capabilities separately.

**Question 6-1: Regarding IoT bits for existing TN UE capabilities, which option can be adopted?**

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| **Company** | **option 0/1/2/3** | **Additional comments** |
| Qualcomm | Option 1 | It is simple, risk free and less time consuming. |
| Apple | Option 0 | We don’t think Option 1 is that much simpler than Option 0, since we are anyways using UE\_NR\_Capability for Option 1, and so have to figure out which capabilities are needed/not needed for NTN. Option 0 is more flexible as well. |
| Huawei, HiSilicon | Option 0 |  |
| Samsung | Option 0 or 1 (see comment) | With option1, it sounds we’ll have separate IoT bits for all capabilities defined as per-UE capability, which could be acceptable from the signalling overhead point of view. Then one remaining question is how to handle any IoT bit for per-band or per BC capabilities? |
| OPPO | Option 1 | It is the simplest and can be error free. |
| vivo | 1 | In case that there is no motivation for a case by case study. |
| Xiaomi | Option 0 or option 1 |  |
| NEC | Option1 | Simple and saft, overhead would not be a problem. But ASN.1 needs to avoid recursive loop |
| Nokia | Option 1 |  |
| Ericsson | Option 2 (or, if really needed, Option 0 if per UE capabilities with few added bits, e.g. only 5 or 6 extra bits) | Option 2 work well.  When the UE is in a TN, the UE capabilities indicated are for TNs and the terrestrial network can use the *nonTerrestrialNetwork* capability to know if NTN is supported or not.  After the UE connects to an NTN, the basic NTN capabilities are supported. The NTN node can request the UE to report UE capabilities, and the UE then reports the NTN UE capabilities which may differ from the TN capabilities.  It may even be assumed that if a UE supports a capability in NTN, then that is also supported in TN. If that is not the case, then the terrestrial network must request the UE capabilities after a handover from an NTN.  Option 0 will require going through all capabilities and identify the ones that need IoT bit and will increase the size of the UE capabilities, though not nearly as bad as Option 1 and Option 3. Option 0 may be acceptable if only a few per UE capabilities are identified (adding, e.g., 5 or 6 bits is OK).  Option 1 and Option 3 seems like overkill and result in a doubling of the size for UE capability signalling without a clear gain. A similar case was the UE capability signalling for NR-U introduced in R16, where such a solution was not agreed, only parameters per specific bands were defined. Handovers within TNs respectively within NTNs are much more frequent than HO between TNs and NTNs. Further, HO from TN to NTN are most likely not needed/possible in urban areas as TN coverage is good while satellite coverage may be very challenging, thus always reporting all capabilities is not efficient usage of the resources. Simplicity is not good if UE capability signalling is doubled.  The UE capability signalling is already very large thus we think we shall avoid Option 0, 1 and 3 for that reason alone. |
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**Question 6-2: Proponent companies for option 0, please further provide the list of existing UE capabilities which need NTN IoT bits.**

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| **Company** | **list of existing UE capabilities** |
| Huawei, HiSilion | The check and review work of Option 0 does not necessarily take place during the meeting. Companies can check internally offline, and if some capabilities are identified to need extra capability, it can be raised by company contributions to the next meeting. If no such capabilities are raised, then it is natural that current capabilities apply to both TN and NTN.  We think the capabilities raised by Qualcomm can be a good starting point for discussion: MAC parameters, measurement parameters, SON/MDT, RRC\_INACTIVE.  Our understanding is that, at least SON/MDT can have separate capabilities for NTN (there’s no need for UEs capable of SON/MDT in TN to also support SON/MDT in NTN as well).  There could also be discussion on whether the PHY parameters need to be separate for NTN, e.g. MIMO related capabilities. |
| Ericsson | If Option 0 is selected, only per UE capabilities shall be used and it is only acceptable if this adds few extra capabilities. |
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**Question 6-3: Proponent companies for option 1, do you agree that “option 1 is only for "per-UE" capabilities”?**

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| --- | --- | --- |
| **Company** | **option 0/1/2/3** | **Additional comments** |
| Qualcomm | Yes | Existing per band capabilities and feature sets can be used as today. So we need to address only per UE capabilities. |
| Samsung | No | If a feature is IoTed in a TN band and NTN uses the same band, UE also needs to indicate the IoT bit of the feature for NTN. May need input from RAN1/RAN4 |
| OPPO | Yes |  |
| vivo | Comments | Share the view of Samsung. |
| Xiaomi | Yes |  |
| Nokia |  | Agree with Samsung. |
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**Question 6-4: Proponent companies for option 2 or 3, do you agree option2/3 has impact on RAN3 (e.g., when RAN exchanges UE capability with CN, the UE capability type (TN or NTN) needs to be indicated), and RAN2 needs to send a LS to RAN3 if option2/3 is adopted?**

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| --- | --- | --- |
| **Company** | **option 0/1/2/3** | **Additional comments** |
| Ericsson | Option 2: No | The UE capabilities a node retrieves from the CN are, in general, the ones that the node retrieved from the UE previously, i.e. usually the NTN node will not transfer its UE capabilities to the TN node via the CN, this would be done upon HO. At a HO between a TN node and NTN node, the target node will require the UE to report the UE capabilities so there is no RAN3 impact needed. |
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**Summary:**

Two companies only support option 0, 7 companies are fine with option 1 and one company strongly supports option 2.

For option 0, one company suggests to check internally after this meeting, and bring up the list of NTN IoT UE capabilities by papers to next meeting. The candidate features which may need NTN IoT bits can be MAC parameters, measurement parameters, SON/MDT, RRC\_INACTIVE.

For option 1, further question is whether “a feature is IoTed in a TN band and NTN uses the same band”. According to the latest RAN4 progress [7], NTN will have separate band numbers, so NTN and TN will not use the same band.

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| --- |
| * 1. Issue 1-2-1: NTN Band Coding and Signalling Design   1st round GTW Agreement (20/08/2021):  Introduce NTN band numbering respecting existing band coding and signalling design without changes on RAN2.   * 1. Issue 1-2-2: NTN Band Numbering   1st round GTW Agreement (20/08/2021):  Starting from the largest band number in FR1 range for NTN bands which fully within FR1 frequency ranges, the number can be taken in a decreased order with first come, first service.  FFS with prefix as “n’ or “s”. A note can be included to clarify the usage of NTN bands. |

Except for this question, other proponents agree only per-UE capabilities need to have IoT bits for NTN, i.e. existing band/band combination related UE capabilities are only for TN.

For option 2, it means the terrestrial network must request the UE capabilities after a handover from an NTN, and vice versa. But the benefit is we don’t need to enlarge UE capability signalling overhead especially considering it’s already very large.

Rapporteur suggests to further discuss the following options with more details:

**Option 0**: Identify which existing capabilities should have IoT bits for NTN. For other existing UE capabilities, when a NTN capable UE indicates it, it means this UE capability is supported in both TN and NTN. The candidate features which may need NTN IoT bits can be MAC parameters, measurement parameters, SON/MDT, RRC\_INACTIVE. The work plan is to postpone this discussion to next meeting, after checking internally companies are supposed to bring up papers with the list of existing UE capabilities which need NTN IoT bits in next meeting.

**Option 1**: Define an embedded ASN.1 structure for NTN IoT bits as below, and only per-UE capabilities need to have NTN IoT bits, i.e., existing band/band combination related UE capabilities are only for TN.

UE-NR-Capability ::= SEQUENCE {

<Unnecessary parts omitted>

iotBitsNTN UE-NR-Capability OPTIONAL,

<Unnecessary parts omitted>

}

**Option 2:** Existing capability signalling is used but only valid in the network type it is reported to (e.g. when UE reports to NTN network the capability refers to NTN and not TN). It means the TN must request the UE capabilities after a handover from an NTN, and vice versa. Since the NTN node will not transfer its UE capabilities to the TN node via the CN, there is no RAN3 impact needed.

**Proposal 2: Regarding NTN IoT bits for existing TN UE capabilities, RAN2 to further discuss the following options:**

**Option 0**: Identify which existing capabilities should have IoT bits for NTN. For other existing UE capabilities, when a NTN capable UE indicates it, it means this UE capability is supported in both TN and NTN. The candidate features which may need NTN IoT bits can be MAC parameters, measurement parameters, SON/MDT, RRC\_INACTIVE. The work plan is to postpone this discussion to next meeting, after checking internally companies are supposed to bring up papers with the list of existing UE capabilities which need NTN IoT bits in next meeting.

**Option 1**: Define an embedded ASN.1 structure for NTN IoT bits as below, and only per-UE capabilities need to have NTN IoT bits, i.e., existing band/band combination related UE capabilities are only for TN.

UE-NR-Capability ::= SEQUENCE {

<Unnecessary parts omitted>

iotBitsNTN UE-NR-Capability OPTIONAL,

<Unnecessary parts omitted>

}

**Option 2:** Existing capability signalling is used but only valid in the network type it is reported to (e.g. when UE reports to NTN network the capability refers to NTN and not TN). It means the TN must request the UE capabilities after a handover from an NTN, and vice versa. Since the NTN node will not transfer its UE capabilities to the TN node via the CN, there is no RAN3 impact needed.

**IoT bits for different NTN scenarios:**

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| --- |
| **Proposal 6: Since it should not be assumed that every NTN capable UE has been tested to support both GSO and NGSO, define IoT bits for the support of {GSO, NGSO, both} and this indication means all NTN essential features and optional features UE indicates have been tested in the corresponding scenario(s).**  **Proposal 11: RAN2 to discuss whether** **IoT bit for the support of {both GSO and NGSO} means UE also supports mobility between GSO and NGSO.** |

In the first round of this discussion, the majority view is to have this IoT bit to indicate whether the support of one NTN scenario has been tested successfully (including all NTN essential features and optional features UE indicates). The spec change may be like:

In 38.331:

ntn-ScenarioSupport-r17 ENUMERATED {GSO, NGSO, both} OPTIONAL,

In 38.306:

| ***ntn-ScenarioSupport-r17***  Indicates the support of which NTN scenario has been tested successfully, including all NTN essential features and optional features UE indicates. *both* represents both GSO and NGSO. The field is mandatory when UE supports *nonTerrestrialNetwork-r17*. | UE | CY | N/A | N/A |
| --- | --- | --- | --- | --- |

**Question 7-1: whether the following proposal is agreeable?**

**Proposal 6: Since it should not be assumed that every NTN capable UE has been tested to support both GSO and NGSO, define IoT bit for the support of {GSO, NGSO, both} and this indication means all NTN essential features and optional features UE indicates have been tested in the corresponding scenario(s).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y or N** | **Additional comments** |
| Thales | Yes |  |
| Qualcomm | See comments | It says every essential and optional features.  What if, for GEO or LEO, only some features cannot be tested. How this would be handled. |
| Apple | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Samsung | Yes |  |
| OPPO | Yes |  |
| vivo | See comments | Similar view as Qualcomm.  In addition, maybe OK to have one such indicator applied to all NTN essential features. But for optional features, can’t there be the possibility that the UE selects to implement (and test) some of them for NGSO, but some others for GSO? |
| Xiaomi | Yes |  |
| NEC | Yes |  |
| Nokia | Yes |  |
| Ericsson | No | The essential features are always supported if *nonTerrestrialNetwork* is indicated.  We do not see the need to differentiate this between GSO and NGSO. Why else are the capabilities essential? |

**Summary:**

The majority companies agree to define IoT bit for the support of {GSO, NGSO, both} and this indication means all NTN essential features and optional features UE indicates have been tested in the corresponding scenario(s). But also some companies wonder if we also need to allow the flexibility that the UE selects to implement (and test) some of optional features for NGSO, but some others for GSO.

**Proposal 3:** **Regarding NTN IoT bits for different NTN scenarios, RAN2 to further discuss the following options:**

**Option 1:** Define IoT bit for the support of {GSO, NGSO, both} and this indication means all NTN essential features and optional features UE indicates have been tested in the corresponding scenario(s). The spec change may be like:

ntn-ScenarioSupport-r17 ENUMERATED {GSO, NGSO, both} OPTIONAL,

nonTerrestrialNetwork-r17 ENUMERATED {supported} OPTIONAL,

**Option 2**: In order to support more flexibility, define IoT bit for the support of essential features in {GSO, NGSO, both}, and define separate IoT bits for the support of each optional features in {GSO, NGSO, both}. The spec change may be like:

harqFeedbackDisabled-r17 ENUMERATED {GSO, NGSO, both} OPTIONAL,

locationBasedCondHandover-r17 ENUMERATED {GSO, NGSO, both} OPTIONAL,

nonTerrestrialNetwork-r17ENUMERATED {GSO, NGSO, both} OPTIONAL,

During the discussion on SMTC UE capabilities, one question is raised to discuss whether the mobility between GSO and NGSO is supported. So the following question is used to collect companies’ views.

**Question 7-2: Whether** **the** **IoT bit for the support of {both GSO and NGSO} also means** **UE supports mobility between GSO and NGSO?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y or N** | **Additional comments** |
| Thales | Yes |  |
| Qualcomm | Yes |  |
| Apple | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Samsung | Yes |  |
| OPPO | Yes |  |
| vivo | Yes |  |
| Xiaomi | Yes |  |
| NEC | Y | We do not see the difference to handle a HO between GSO and NGSO from intra-system HO |
| Nokia | Y | Agree, this should be regarded as a HO within the same system and RAT. |
| Ericsson | Y | If *nonTerrestrialNetwork* is indicated, HO shall be possible with the NTN essential features, but no {GSO, NGSO, both} IoT bit is needed. |

**Summary:**

Almost all companies agree that the IoT bit for the support of {both GSO and NGSO} also means UE supports mobility between GSO and NGSO. We can extract the common part and leave the IoT bits part for further discussion.

**Proposal 4: RAN2 confirms that, if UE supports both GSO and NGSO, it means UE also supports mobility between GSO and NGSO.**

## Third round

In this round of offline discussion, we focus on the IoT bits for TN capabilities and different NTN scenarios.

**IoT bits for existing TN UE capabilities**

As the outcome of second round, all the candidate options have been clarified based on companies’ views.

The three options on the table are as follows:

**Option 0**: Identify which existing capabilities should have IoT bits for NTN. For other existing UE capabilities, when a NTN capable UE indicates it, it means this UE capability is supported in both TN and NTN. The candidate features which may need NTN IoT bits can be MAC parameters, measurement parameters, SON/MDT, RRC\_INACTIVE. The work plan is to postpone this discussion to next meeting, after checking internally companies are supposed to bring up papers with the list of existing UE capabilities which need NTN IoT bits in next meeting.

**Option 1**: Define an embedded ASN.1 structure for NTN IoT bits as below, and only per-UE capabilities need to have NTN IoT bits, i.e., existing band/band combination related UE capabilities are only for TN.

UE-NR-Capability ::= SEQUENCE {

<Unnecessary parts omitted>

iotBitsNTN UE-NR-Capability OPTIONAL,

<Unnecessary parts omitted>

}

**Option 2:** Existing capability signalling is used but only valid in the network type it is reported to (e.g. when UE reports to NTN network the capability refers to NTN and not TN). It means the TN must request the UE capabilities after a handover from an NTN, and vice versa. Since the NTN node will not transfer its UE capabilities to the TN node via the CN, there is no RAN3 impact needed.

And the comparison is also done based on companies’ input as shown in this following table.

|  |  |  |
| --- | --- | --- |
|  | Pros | Cons |
| Option 0 | Compared to option 1, less additional UE capability signalling overhead for NTN IoT bits. | Not clear how many NTN IoT bits are needed, and we need to postpone this discussion to next meeting for the exact list of NTN IoT bits. |
| Option 1 | Simple, risk free and less time consuming | Potentially double the UE capability signalling overhead in per UE capability aspect. |
| Option 2 | No additional UE capability signalling overhead for NTN IoT bits | The TN must request the UE capabilities after a handover from an NTN, and vice versa. |

**Question 8: Regarding IoT bits for existing TN UE capabilities, which option (option 0/1/2) can be adopted? Please also provide arguments (if any) on why other options are not feasible.**

|  |  |  |
| --- | --- | --- |
| **Company** | **option 0/1/2** | **Additional comments** |
| Qualcomm | Option 1 | For Option 3, how does it work requesting capability after handover? Without capability, the handover even could not be started.  Option 1 should be the starter and after further refining, we can end up solution like option 0. For option 1, we can still define which do not need to be included ( i.e., option 0) as we go over. |
| Samsung | Option 0 | For option 1, it’s not clear how it works for per band, or per band combination UE capability case, as TN and NTN bands overlap. Also note it brings more signaling overheads. For option 2, service interruption or delay may be brought in HO between TN and NTN, and bring same (or more) overheads as option 1 when there is any handover between TN and NTN. |
| Intel | updated option 2 | NW can rely on existing band filter mechanism to request NTN only UE capabilities, i.e., only NTN bands are included in *frequencyBandListFilter*, then the reported UE capabilities (e.g., using existing UE capability signalling) are valid in NTN. To avoid ambiguity, specify a restriction that NW doesn’t add both TN bands and NTN bands in *frequencyBandListFilter*. |
| Huawei, HiSilicon | Option 0 | Option 1 means doubling the capability overhead.  Option 2 does not work well in HO case between TN and NTN since the source node has no UE capability during HO preparation. |
| OPPO | Option 1 | For option 2, we share the same view as QC that it does not work. |
| vivo | Option 1 or Option 0 | We prefer Option 1 which is of better flexibility and readability. Also, agree with some companies’ views in the previous round to avoid recursive loop in the ASN.1. Option 0 is also fine to us if the majority wants it. |
| Xiaomi | Option 0 or Option 1 | Both option 0 and option 1 are OK for us.  There are some issues for Option 2 in HO between TN and NTN. |
| Lenovo | Option 0 or Option 1 |  |
| Ericsson | Option 0 or Option 2 | For Option 2, it seems there are some misunderstandings. For performing a handover, it should already be clear what basic capabilities that are supported in order for the network to request capabilities after having performed handover. Similar to when a UE performs initial access – the UE can of course communicate with the network before capabilities are exchanged.  For Option 1 it has not been clear what specific capabilities where there is a lot of problems that motivate this option. We have already spent a lot of time finding adaptations needed for many core features of Rel-15 and Rel-16. This was not for instance done for other features such as unlicensed where it could similarly be argued that features need to be tested. |
|  |  |  |
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**IoT bits for different NTN scenarios:**

In the second round, the majority companies agree to define IoT bit for the support of {GSO, NGSO, both} and this indication means all NTN essential features and optional features UE indicates have been tested in the corresponding scenario(s). But also some companies wonder if we also need to allow the flexibility that the UE selects to implement (and test) some of optional features for NGSO, but some others for GSO.

The two options on the table are as follows:

**Option 1:** Original approach.

Define IoT bit for the support of {GSO, NGSO, both} and this indication means all NTN essential features and optional features UE indicates have been tested in the corresponding scenario(s). The exemplary spec change may be like:

ntn-ScenarioSupport-r17 ENUMERATED {GSO, NGSO, both} OPTIONAL,

nonTerrestrialNetwork-r17 ENUMERATED {supported} OPTIONAL,

**Option 2**: Enhanced approach.

In order to support more flexibility, define IoT bit for the support of essential features in {GSO, NGSO, both}, and define separate IoT bits for the support of each optional features in {GSO, NGSO, both}. The exemplary spec change may be like :

harqFeedbackDisabled-r17 ENUMERATED {GSO, NGSO, both} OPTIONAL,

locationBasedCondHandover-r17 ENUMERATED {GSO, NGSO, both} OPTIONAL,

nonTerrestrialNetwork-r17ENUMERATED {GSO, NGSO, both} OPTIONAL,

**Question 9: Regarding IoT bits for different NTN scenarios, which option (option 1/2) can be adopted?**

|  |  |  |
| --- | --- | --- |
| **Company** | **option 1/2** | **Additional comments** |
| Qualcomm | Option 3 | Option 2 may be too much time consuming. We are open to discuss other approach, for example, option 1 for mandatory/essential features and option 2 for optional features.  ntn-ScenarioSupportMandatory -r17 ENUMERATED {GSO, NGSO} OPTIONAL,  ”both” is not needed, it can be implicit from absence. |
| Samsung | Option 1 |  |
| Intel | Option 1 |  |
| Huawei, HiSilicon | Option 1 | No need to have separate IoT bits for all features. |
| OPPO | Option 2 | We prefer more flexible indication. |
| vivo | Option 2 | This can give more flexibility to UE implementation. But we’re also fine to follow majority’s views on whether such flexibility is worth pursuing. |
| Xiaomi | Option 2 | Option 2 is more flexible. |
| Lenovo | Option 1 |  |
| Ericsson | Option 1 | Can option 1 be compressed into a single parameter:  nonTerrestrialNetwork-r17 ENUMERATED {GSO, NGSO, both} OPTIONAL,  For option 2 we do not see any technical reason why the support for HARQ feedback disabled and location based conditional handover should be different for NGSO or GSO. Why the flexibility is needed is not clear. |
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# Conclusion

Based on this offline discussion on UE capabilities, the following proposals are made:

** List of proposals for agreement:**

**Proposal 1: the UE capabilities for time based CHO and Event A4 based CHO are optional with capability signalling.**

**Proposal 4: RAN2 confirms that, if UE supports both GSO and NGSO, it means UE also supports mobility between GSO and NGSO.**

** List of proposals that require online discussions:**

**Proposal 2: Regarding NTN IoT bits for existing TN UE capabilities, RAN2 to further discuss the following options:**

**Option 0**: Identify which existing capabilities should have IoT bits for NTN. For other existing UE capabilities, when a NTN capable UE indicates it, it means this UE capability is supported in both TN and NTN. The candidate features which may need NTN IoT bits can be MAC parameters, measurement parameters, SON/MDT, RRC\_INACTIVE. The work plan is to postpone this discussion to next meeting, after checking internally companies are supposed to bring up papers with the list of existing UE capabilities which need NTN IoT bits in next meeting.

**Option 1**: Define an embedded ASN.1 structure for NTN IoT bits as below, and only per-UE capabilities need to have NTN IoT bits, i.e., existing band/band combination related UE capabilities are only for TN.

UE-NR-Capability ::= SEQUENCE {

<Unnecessary parts omitted>

iotBitsNTN UE-NR-Capability OPTIONAL,

<Unnecessary parts omitted>

}

**Option 2:** Existing capability signalling is used but only valid in the network type it is reported to (e.g. when UE reports to NTN network the capability refers to NTN and not TN). It means the TN must request the UE capabilities after a handover from an NTN, and vice versa. Since the NTN node will not transfer its UE capabilities to the TN node via the CN, there is no RAN3 impact needed.

**Proposal 3:** **Regarding NTN IoT bits for different NTN scenarios, RAN2 to further discuss the following options:**

**Option 1:** Define IoT bit for the support of {GSO, NGSO, both} and this indication means all NTN essential features and optional features UE indicates have been tested in the corresponding scenario(s). The spec change may be like:

ntn-ScenarioSupport-r17 ENUMERATED {GSO, NGSO, both} OPTIONAL,

nonTerrestrialNetwork-r17 ENUMERATED {supported} OPTIONAL,

**Option 2**: In order to support more flexibility, define IoT bit for the support of essential features in {GSO, NGSO, both}, and define separate IoT bits for the support of each optional features in {GSO, NGSO, both}. The spec change may be like:

harqFeedbackDisabled-r17 ENUMERATED {GSO, NGSO, both} OPTIONAL,

locationBasedCondHandover-r17 ENUMERATED {GSO, NGSO, both} OPTIONAL,

nonTerrestrialNetwork-r17ENUMERATED {GSO, NGSO, both} OPTIONAL,

# References

1. [R2-2202454](file:///C:\Data\3GPP\Extracts\R2-2202454%20Report%20of%20email%20discussion%20%5bPre117-e%5d%5b104%5d%5bNTN%5d%20UE%20caps%20open%20issues%20(Intel).docx) Report of email discussion [Pre117-e][104][NTN] UE caps open issues (Intel)

Intel Corporation

1. [R2-2202454](file:///C:\Data\3GPP\Extracts\R2-2202454%20Report%20of%20email%20discussion%20%5bPre117-e%5d%5b104%5d%5bNTN%5d%20UE%20caps%20open%20issues%20(Intel).docx) List of open issues on NR NTN UE capabilities Intel Corporation
2. [R2-2203485](file:///C:\Data\3GPP\Extracts\R2-2203485%20-%20NR%20NTN%20UE%20capabilities.docx) NR NTN UE capabilities Ericsson
3. [R2-2202725](file:///C:\Data\3GPP\Extracts\R2-2202725%20Remaining%20Issues%20of%20Set2%20on%20NR%20NTN%20UE%20Capabilities.docx) Remaining Issues of Set2 on NR NTN UE Capabilities CMCC
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6. R4-2115640 Way Forward on NTN\_solutions\_Part1 Thales