**3GPP T****SG-RAN WG2 Meeting #116-bis-e R2-22xxxxx**

**E-Meeting, Jan 17th – Jan 25th, 2022**

**Agenda item:**  **8.10.4**

**Source: Intel Corporation**

**Title: Report of email discussion [AT116bis-e][112][NTN] Capabilities (Intel)**

**Document for: Discussion**

# Introduction

This is the report of the following email discussion:

**[AT116bis-e][112][NTN] Capabilities (Intel)**

Initial scope: Continue the discussion on NTN capabilities, based on [R2-2200040](file:///C:\Data\3GPP\Extracts\R2-2200040%20Report%20of%20email%20discussion%20%5bPost116-e%5d%5b111%5d%5bNTN%5d%20UE%20capabilities%20(Intel).docx) and possibly other company contributions

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 2022-01-24 1400 UTC

Initial deadline (for rapporteur's summary in R2-2201748): Monday 2022-01-24 1600 UTC

Proposals marked "for agreement" in R2-2201748 not challenged until Tuesday 2022-01-25 0800 UTC will be declared as agreed via email by the session chair (for the rest the discussion might continue in the GTW session).

# Discussion

During the online discussion, the following agreements were achieved:

Agreements:

1. define one single NR NTN UE capability to encompass essential features to support NTN, and UE can further indicate other optional capabilities.
2. gnss-Location-r16 is conditionally mandatory when UE indicates the support of NR NTN access, and update the field description to cover NTN case.
3. consider the following differentiation of user plane enhancements as baseline:

Essential sub-features include:

1) the adaptations of RACH;

2) DRX HARQ RTT timer extension;

3) the timer extension to accommodate long RTT for other MAC timers (e.g., extended sr-ProhibitTimer);

4) the timer extension to accommodate long RTT in RLC and PDCP layers (FFS for LEO)

Optional sub-features include:

1) TA reporting (TA reporting during RACH using MAC CE, and Event-triggers for TA reporting in connected mode);

2) disabling HARQ feedback for downlink transmission;

3) new HARQ state for uplink transmission and the corresponding new LCP mapping rule for dynamic grants.

4. consider the following differentiation of control plane enhancements as baseline:

Essential sub-features include (for NGSO, FFS for GEO):

1) soft TAC update;

2) SMTC enhancements (event-triggered assistance information reporting, 2 SMTC in parallel);

Optional sub-features include:

1) cell stop-time based neighbour cell measurements;

2) location based cell reselection criteria;

3) SMTC enhancements (4 SMTC in parallel and UE based solution in idle/inactive);

4) CHO enhancements (location based CHO).

FFS if CHO enhancements (time based and Event A4 based CHO) is essential or optional

1. Postpone the UE capability discussion on location reporting

Working Assumption (further check if anything can be per band):

1. the granularities of all the optional RAN2 determined sub-features with capability signalling are per UE.

In this offline discussion, companies could further discuss the FFS issues highlighted above. The wording NGSO represents LEO and MEO.

## Differentiation of UE capabilities between GSO and NGSO (LEO, MEO)

**RLC timer extension**

Regarding the following FFS:

4) the timer extension to accommodate long RTT in RLC and PDCP layers (FFS for LEO)

Current agreements on RLC and PDCP timers are as below:

Agreements:

1. RLC t-Reassembly timer needs to be extended in NR-NTN.
2. There is no need to extend t-PollRetransmit Timer in NR-NTN.
3. There is no need to extend t-statusProhibit Timer in NR-NTN.
4. There is no need to extend RLC SN length in NR-NTN
5. There is no need to extend PDCP SN length in NR-NTN

Agreements:

1. The UE utilizes the t-Reassembly timer value that does not depend on the time-varying UE-gNB delay.
2. The value range of t-Reassembly shall be extended. The following set of values are possibly added for t-Reassembly timer: {ms210, ms220, ms340, ms350, ms550, ms1100, ms1650, ms2200}. Any other values are FFS.
3. The network can configure the values of PDCP discardTimer and PDCP t-Reordering timer greater than the RLC t-Reassembly timer.
4. Extend the range of the PDCP discardTimer and the PDCP t-reordering timer. One option is to enlarge the set of allowed values for the PDCP discardTimer and the PDCP t-reordering timer. The exact values FFS

Agreements:

1. Introduce a new t-ReassemblyExt-r17 IE, which is optional present for NTN network scenario.
2. Introduce a new discardTimerExt-r17 IE with a new value ms2000 and several spare bits for future extension.
3. RAN2 consider not to extend PDCP t-Reordering timer or use several spare bits in legacy IE to add several greater values up to 4400ms.

t-Reassembly timer is the only timer that needs to be extended in RLC layer, and new values are {ms210, ms220, ms340, ms350, ms550, ms1100, ms1650, ms2200}. These values come from [1], and they are calculated based on formula below:

*t-Reassembly = RTD ∙ nrofHARQ-Retransmissions + schedulingOffset,* (1)

while it assumes the number of HARQ retransmissions to be {1, 2, 3, 4, or 8} for LEOs and {1, 2, 3, 4} for GEOs, and the RTD values are listed in Table 1.

**Table 1 Maximum Round Trip Delay for different reference scenarios**

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| --- | --- | --- |
|  | Orbit, payload | Max. RTD |
| Scenario A | GEO, transparent | 541.46ms |
| Scenario C | LEO, transparent | 25.77ms (600km)  41.77ms (1200km) |

So it can be seen that the first four values, i.e., {ms210, ms220, ms340, ms350}, are for NGSO; and the latter four values, i.e., {ms550, ms1100, ms1650, ms2200} are for GSO. It means RLC timer extension has been agreed to accommodate long RTT for both GSO and NGSO, thus it’s essential for both GSO and NGSO considering it is used for normal data transmission/reception.

**Question 1: Do you agree that the RLC timer extension (i.e., t-Reassembly timer) to accommodate long RTT is also essential for NGSO?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| Thales | Agree | Note that typically MEO corresponds to an altitude of 10000 – 20000 km  For MEO, the Max Round Trip Delay (propagation delay only) accounts 95.19 ms (transparent) and 47.60 ms (regenerative) for 10000 km. Therefore RLC timer extension are also needed for NGSO (See R4-2119300) |
| NEC | Agree | We agree with the analysis from rapporteur. |
| Qualcomm | Agree | Considering only scenario A and C is not complete. First let’s look at the definition of NGSO we agreed after putting a lot of effort. NGSO also includes MEO for which RTT can be close to that of GEO.  *Non-Geosynchronous orbit (NGSO) includes Low Earth Orbit at altitude approximately between 300 km and 1500 km and Medium Earth Orbit at altitude approximately between 7000 km and 25000 km.* |
| Apple | Agree | Agree with analysis from companies above. |
| LG | Agree |  |
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**PDCP timer extension**

Currently the only principle is that it’s up to network implementation to guarantee “the values of PDCP discardTimer and PDCP t-Reordering timer greater than the RLC t-Reassembly timer”. And the following agreements are only for GSO to accommodate up to 541.46ms RTD:

1. Introduce a new discardTimerExt-r17 IE with a new value ms2000 and several spare bits for future extension.
2. RAN2 consider not to extend PDCP t-Reordering timer or use several spare bits in legacy IE to add several greater values up to 4400ms.

**Question 2: Do you agree that the PDCP timer extension (i.e., discardTimer and t-Reordering timer) to accommodate long RTT is only essential for GSO?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| Thales | Disagree | It should also apply to NGSO at altitude of 20000 km |
| NEC | Agree but | Would it be simpler to have this (only one value) as being essential for both GSO and NGSO?  Moreover, since there is relationship between the PDCP t-Reordering timer and the RLC t-Reassembly timer, it is better to handle them the same way. |
| Qualcomm | Disagree | See our response in Q1. MEO satellites at high altitude (NGSO) may also need this extension. |
| Apple | Disagree | If we agree to RLC timer extension for NGSO (see Q1), then it stands to reason that PDCP timers will also need to be extended. |
| LG | Disagree | It should also apply to NGSO case. In addition, since the configuration is up to network implementation, there is no reason to restrict the configuration of extended discardTimer and extended t-Reordering only for GSO. |
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**Multiple TACs**

The following agreements are on “multiple TACs” aspect:

Agreements:

1. In NTN, the UE determines the TA based on the broadcast information (the use of other information is not excluded). In any case RAN2 will not go in a different direction than other groups
2. In NTN, the network may broadcast more than one TACs per PLMN in a cell, which is to up to network implementation.

Agreements:

1. RAN2 assume UE does not do TAU if one of the currently broadcasted TAC belongs to UE’s registration area.

Agreements via email - from offline 107:

1. RAN2 confirms AS indicates to NAS layer all received TACs per PLMN.
2. RAN2 responds to CT1 and SA2 with the confirmation that AS indicates to NAS layer all received TACs per PLMN. In addition it is stated that TACs in NTN are fixed to geographical location on Earth and UE’s location information can be used for TAI selection. Final decision on which criteria to apply (e.g. UE location information or other) is anyway up to CT1 and SA2 judgement

So the UE should be able to derive multiple TACs per PLMN in a cell, and indicate to NAS layer all received TACs per PLMN. Considering “TACs in NTN are fixed to geographical location on Earth”, and the beam size of GSO is even larger than that of NGSO which means both GSO cell and NGSO cell can cover multiple TACs on ground. It’s reasonable to assume multiple TACs feature is essential for both GSO and NGSO.

**Question 3: Do you agree that Multiple TACs feature (i.e., UE should be able derive multiple TACs per PLMN in a cell, and indicate to NAS layer all received TACs per PLMN) is essential for both GSO and NGSO?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| Thales | Agree | Given that Max beam foot print size (edge to edge) regardless of the elevation angle can be up to 3500 km (GSO) and up to 1500 km (NGSO/MEO), it is most likely that a beam/radio cell cover several TACs |
| NEC | Depends | we agree it is also possible for a GSO cell broadcast multiple TACs due to large cell size. However, these broadcast TACs in SIB1 likely will be removed/added/update frequently for an earth moving cell, but will not for other cell type.  We have agreed to use system information update procedure to inform UE the TAC update, but last meeting there were still discussion whether other solution e.g., validity timer is needed and no conclusion. If no other solution will be agreed, then same capability can be applicable for both GSO and NGSO. If extra solution is agreed, then we need define different capabilities for GSO and NGSO, because handling validity timer and or checking SI for TAC update automatically would be only needed for earth moving cell case. |
| Qualcomm | Agree | This is the feature to be used in IDLE mode so probably this is essential feature without capability signaling because as per current RRC running CR, the legacy TAC code will not be used for SOFT TAC update. |
| Apple | Agree |  |
| LG | Agree | Regardless of whether GSO or NGSO, one cell may cover multiple tracking area, both need to support the multiple TACs feature. |
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**SMTC enhancements**

Currently the agreements on SMTC aspect are as below:

Agreements via email - from offline 103 (second round):

1. UE assistance information for NTN SMTC adjustments is event-triggered. Details of the triggering event are FFS (pending the decision on supported assistance information type).
2. RAN2 aims to minimize the number of configurable measurement gaps required for monitoring configured SMTCs in NTN. At least gap length and UE capabilities impact the number of required measurement gaps.
3. UE-based solution for SMTC adjustments in NTN is supported for IDLE/INACTIVE UEs. FFS how does the UE perform the necessary shifts in SMTC.

Agreements:

1. In NW-based solution, the network can configure up to 2 SMTCs in parallel and the UE uses all of them, i.e. there is no switching between or activation/deactivation of configured SMTCs. FFS whether this (UE support for 2 SMTCs) requires a UE capability. A UE can optionally indicate support for 4 SMTCs (in this case the NW can configure up to 4 SMTCs in parallel)

The network based SMTC adjustment has been agreed with up to 2 SMTCs in parallel and event-triggered report of UE assistance information. This enhancement is mainly for moving satellite case where the SMTC may need to change along with the movement of satellites of neighbour cells. For GSO case, since the satellite is “fixed” this enhancement is not essential.

**Question 4: Do you agree that enhanced SMTC feature (i.e., event-triggered assistance information reporting, 2 SMTC in parallel) is not essential for GSO?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| NEC | Agree |  |
| Qualcomm | Disagree | We disagree partly. The reason is that some UEs can still be in cell edge of GEO and in reality GEO cell coverage could still be moving very slowly. Either we need to confirm that mobility from GEO to NGSO is not supported, otherwise enhanced SMTC features would also be needed when camping in GSO. |
| Apple | Agree |  |
| LG | Agree | As their propagation delay is very long, we do not need to split the capabilities for GSO and NGSO. |
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**CHO enhancements**

According to the outcome of offline discussion [2], CHO enhancements (time based and Event A4 based CHO) are considered to be essential. One reason is that Event A3 may not work well due to unobvious near-far effect in NTN, so other triggers should be considered instead. Meanwhile CHO can reduce the mobility interruption considering long RTT. But one company showed concern about location-based CHO which requires UE to perform GNSS fixes and lead to much power consumption. So time based and Event A4 based CHO are listed as essential. Since the rational above is the same for both GSO and NGSO, it can be assumed that CHO enhancements (time based and Event A4 based CHO) are essential for both GSO and NGSO.

**Question 5: Do you agree that CHO enhancements (time based and Event A4 based CHO) are essential for both GSO and NGSO?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| Thales | Disagree | **CHO (time based and Event A4 based CHO) are essential for NGSO especially in the case of Earth fixed beams. This feature is critical to control the HO rate** |
| NEC | Agree | We agree with the analysis.  With the same reason, the legacy CHO should become essential too |
| Qualcomm | Disagree | For NGSO moving cell, the time based and event A4 based CHO may not work as the network may not have UE’s exact location and network may not configure the time for CHO correctly for the UE.  In addition, even if there is no CHO supported, the NTN system can still work. Therefore, this should be optional feature with capability signaling. |
| Apple | Disagree | Agree with Qualcomm. |
| LG | Agree |  |
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**Need of differentiation of UE capabilities between GSO and NGSO**

During online discussion, the following agreement was made:

1. define one single NR NTN UE capability to encompass essential features to support NTN, and UE can further indicate other optional capabilities.

And in current running CR [3], one UE capability *nonTerrestrialNetwork-r17* is defined to encompass all essential features to support GSO and NGSO. But in both online and offline discussion, companies raised the question whether to define separate UE capabilities for GSO essential features and NGSO essential features.

If the analysis of differentiation of UE capabilities between GSO and NGSO above is agreeable, the essential features for GSO and NGSO can be illustrated in the following Table 2:

**Table 2 essential features for GSO and NGSO**

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|  | GSO | NGSO |
| User Plane | 1) the adaptations of RACH;  2) DRX HARQ RTT timer extension;  3) the timer extension to accommodate long RTT for other MAC timers (e.g., extended sr-ProhibitTimer);  4) the timer extension to accommodate long RTT in RLC and PDCP layers | 1) the adaptations of RACH;  2) DRX HARQ RTT timer extension;  3) the timer extension to accommodate long RTT for other MAC timers (e.g., extended sr-ProhibitTimer);  4) the timer extension to accommodate long RTT in RLC layer |
| Control Plane | 1. multiple TACs; 2. CHO enhancements (time based and Event A4 based CHO) | 1. multiple TACs; 2. SMTC enhancements (event-triggered assistance information reporting, 2 SMTC in parallel); 3. CHO enhancements (time based and Event A4 based CHO) |

**Question 6: Companies are invited to provide views on the following two options:**

**Option 1:** **define single UE capability to encompass all essential features to support both GSO and NGSO. When UE indicates it, it means UE supports all the GSO and NGSO essential features.**

**Option 2: define separate UE capabilities for GSO essential features and NGSO essential features. It means UE indicates the support of GSO and NGSO separately.**

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| **Company** | **Option 1 or 2** | **Additional comments** |
| Thales | Option 1 | NGSO also encompass HEO which behaves temporarily as GSO. Therefore we recommend not to separate UE capabilities for GSO essential features and NGSO essential features |
| NEC | Option2 | We prefer option2. We need one bit for GSO and one bit for NGSO essential feature set, and all sub features which is only essential to GSO or NGSO but not for both would require a capability IE.  Option2 allows UE only supports GSO or NGSO. |
| Qualcomm | Option 2 | It will be cleaner and future proof to have separate indications for GSO and NGSO support.  Additionally, based on Q4 above, we think SMTC enhancements (event-triggered assistance information reporting, 2 SMTC in parallel) should also be listed as essential for GSO. |
| Apple | Option 2 | Option 2 provides more flexibility to UE implementation. We think GSO capabilities are more or less a subset of NGSO capabilities. |
| LG | Option 1 | We do not think separate UE capabilities are needed. |
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## Granularity of NTN UE capabilities

Current agreement on granularities is as follows:

Working Assumption (further check if anything can be per band):

1. the granularities of all the optional RAN2 determined sub-features with capability signalling are per UE.

Besides the essential features discussed in section 2.1, here is the list of optional features:

**Optional UP sub-features include:**

1) TA reporting (TA reporting during RACH using MAC CE, and Event-triggers for TA reporting in connected mode);

2) disabling HARQ feedback for downlink transmission;

3) new HARQ state for uplink transmission and the corresponding new LCP mapping rule for dynamic grants.

**Optional CP sub-features include:**

1) cell stop-time based neighbour cell measurements;

2) location based cell reselection criteria;

3) SMTC enhancements (4 SMTC in parallel and UE based solution in idle/inactive);

4) CHO enhancements (location based CHO).

As TA reporting UE capability is under discussion in RAN1, RAN2 could wait for further input from RAN1. For other essential and optional features (or other candidate features), companies are invited to provide views on which should be per band.

**Question 7: Companies are invited to provide views on which UE capability should be per band.**

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| **Company** | **Per band UE capability** | **Additional comments** |
| Thales |  | In our views, all the above feature are band independent |
| NEC | None |  |
| Qualcomm | Wait | For example, SMTC enhancement could be per band. However, we prefer to wait for RAN1 to conclude first before making final decision on per UE vs per band for these features. |
| Apple | None from R2 perspective |  |
| LG |  | Agree with Thales. |
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## if NTN UE features can be used in TN

According to offline discussion [2], there are two remaining issues for further discussion:

7) Whether to use nonTerrestrialNetwork-r17 as the Prerequisite for other optional NR NTN UE capabilities;

8) Whether to have separate UE capability bit if one essential NTN feature can also be used in TN.

The features developed in this NTN WI are mainly for NTN scenario, but we can also try identifying if some features can also be applied to TN. If there are no features that should be applied in TN, then *nonTerrestrialNetwork-r17* should be the Prerequisite for optional NR NTN UE capabilities. If companies would like to support some NTN feature to be applied in TN as well, *nonTerrestrialNetwork-r17* should not be the Prerequisite for it. And if this UE capability is encompassed in *nonTerrestrialNetwork-r17*, a separate UE capability should be defined.

**Question 8: Companies are invited to provide views on which NTN features should also be applied in TN.**

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| **Company** | **NTN features that can be applied in TN** | **Additional comments** |
| NEC | None | None for now. If any, should this be discussed separately in e.g., NR TEI agenda? |
| Qualcomm | May be | As long as a UE capability can be signaled differently between TN and NTN for these features, we have no issue with the possibility of NTN feature being applicable in TN, if not now then may be in future, it is always better to be future proof. |
| Apple | None |  |
| LG | None |  |
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**Question 9: If some NTN feature is agreed to be applied in TN as well, do you agree with the following handling:**

**If it is an optional feature, *nonTerrestrialNetwork-r17* should NOT be the Prerequisite for it.**

**If it is an essential feature, i.e., the UE capability is encompassed in *nonTerrestrialNetwork-r17*, a separate UE capability should be defined.**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| Qualcomm | Partly agree for optional feature. | We are not clear why it would be different mechanisms for signaling between  (1) NTN essential feature may be or may not be tested in TN  (2) Existing TN essential feature may be or may not tested in NTN.  We should have a common mechanism of signaling, see Q 10. |
| Apple | Disagree | We would prefer not to mix the capabilities for TN and NTN. We are open to signalling optimization e.g., as suggested by Qualcomm. |
| LG | Disagree | Same view as Apple |
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## Need for IoT bits for features which are optional in TN networks

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| 3) Whether to define additional UE capability (or IOT bit) for the existing TN features as they are not tested in NTN environment, e.g., a NTN capable dish-type UE does not support TN;  - Thales thinks that some dish-type UE can support TN. Intel agrees. Nokia agress  - QC thinks that if we don't have IoT bits for the optional features in TN networks  - Huawei thinks this should be a case by case discussion  => Continue the discussion on the need for IoT bits for features which are optional in TN networks on a case by case. |

In this WI, RAN2 focuses on basic and necessary operation to guarantee the normal data transmission and reception in NTN scenarios. Except for 2-step RACH and CHO, RAN2 hasn’t discussed if one optional feature can be applied in NTN.

Agreements:

1. Both 2-step and 4-step RACH are supported in Rel-17 NTN. FFS enhancements to RACH to accommodate the NTN environment.

So the common understanding could be other optional TN features except for 2-step RACH and CHO are NOT supported in NTN.

**Question 10: Do you agree that the other optional TN features except for 2-step RACH and CHO are NOT supported in NTN. If not, please point out which TN features should have IoT bits to indicate whether it can be supported in NTN.**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| Thales | Disagree | We believe that atb least MBS, REDCAP and IAB should be considered to be supported by NTN |
| NEC | Disagree | We understand a TN feature could be optionally supported in NTN as long as it is implemented and tested in NTN environment.  But I think we were discussing different issue online:  For a UE support both NTN and TN, an optional feature e.g., 2-step RACH, it may support it in TN environment but not support or being tested in NTN environment, in this case, the one 2-step RACH IE would not be enough to indicate. In this case, we agree it should be discussed case by case. |
| Qualcomm | Disagree | May be we should clarify our comment. We do not need to worry about the TN mandatory features without signaling.  But any TN features that require signaling today should be discussed (both mandatory and optional features with capability signalling).  It is always the case that there is no guarantee testing is available even for mandatory feature which the UE has already implemented. This should not be overlooked. So, we have two options:  (1) We discuss case by case. This means we may need to spend significant amount of time to check every capability.  (2) We enable signalling possibility for at least MAC parameters, measurement parameters, SON/MDT, RRC\_INACTIVE to be separately indicated for NTN (this does not mean size is double as many parameters would be absent/not applicable).  We think going case by case is a difficult path. Not to mention, RAN2 cannot discuss PHY parameters case by case, it has to be discussed by RAN1.  Therefore, we suggest to start the discussion first with enabling NTN-specific signalling for everything in at least MAC parameters, measurement parameters, SON/MDT, RRC\_INACTIVE. Then it may be possible to refine/shorten the list if some items are readily deemed not applicable.  Further rules can be defined on how to interpret NTN capabilities in presence/absence of NTN-specific signalling, e.g. if all the capabilities between TN and NTN are same, then UE may opt to not include NTN-specific signalling and the TN values apply to both. |
| Apple | Disagree |  |
| LG | Disagree | If there is no critical issue, there is no reason to exclude the TN features in NTN. |
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# Conclusion

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

# References

[1] R2-2101259 Remaining Aspects on Enhancements for NTN on RLC and PDCP Timers Thales

[2] R2-2200040 Report of email discussion [Post116-e][111][NTN] UE capabilities (Intel) Intel Corporation

[3] R2-2200042 Draft 306 CR for NR NTN UE capabilities Intel Corporation