**3GPP T****SG-RAN WG2 Meeting #119bis-e R2-2210860**

**E-Meeting, Oct 10 – 19, 2022**

**Agenda item:**  **8.7.4**

**Source: Intel Corporation**

**Title: Report of [AT119bis-e][117][NR NTN Enh] cell reselection enhancements (Intel)**

**Document for: Discussion and Decision**

# Introduction

This is the report of the following offline discussion on cell reselection enhancements:

* [AT119bis-e][117][NR NTN Enh] cell reselection enhancements (Intel)

Scope: Discuss NTN-NTN and NTN-TN cell reselection enhancements based on remaining proposals in [R2-2209578](file:///C:\Data\3GPP\Extracts\R2-2209578%20Discussion%20on%20NTN%20cell%20reselection%20enhancements.docx) and [R2-2210353](file:///C:\Data\3GPP\Extracts\R2-2210353%20Further%20view%20on%20Idle-%20and%20Connected-mode%20NTN%20mobility%20in%20Rel-18.docx)

Initial intended outcome: Summary of the offline discussion with e.g.:

* List of proposals for agreement (if any)
* List of proposals that require online discussions
* List of proposals that should not be pursued (if any)

Initial deadline (for companies' feedback): Tuesday 2022-10-18 0600 UTC

Initial deadline (for rapporteur's summary in R2-2210860): Tuesday 2022-10-18 0800 UTC

And according to session chair’s guidance, “Regarding [117] and [118], please note that, besides those in the listed papers, the offlines may also consider alternative proposals from other papers, if they are on the same issues as covered in the selected papers. But additional issues/completely separate proposals should be excluded for now (as otherwise the discussions will explode).”

# Discussion

## 2.1 NTN-NTN cell reselection

During the online discussion in first week, the following agreement was achieved as high level guideline:

Agreements:

1. For NTN-NTN cell reselection with earth moving cell, RAN2 will consider providing parameters of serving cell to UE, for UE to estimate when the serving cell stops providing coverage at the present UE location (FFS whether this will be an optional UE feature) (this does not exclude any time-based or location-based approach) (other solutions can also be considered)

In the following sub-sections, a few detailed designs can be discussed based on relevant proposals.

### 2.1.1 Assistance information of serving cell for UE to estimate when the serving cell stops providing coverage at the present UE location

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| Tdoc | Proposals |
| [R2-2209578](file:///C:\Data\3GPP\Extracts\R2-2209578%20Discussion%20on%20NTN%20cell%20reselection%20enhancements.docx) | Proposal 1: For NTN-NTN cell reselection with earth moving cell, to consider providing parameters of serving cell to UE for UE to estimate the stop time of serving cell. These parameters of the serving cell can be satellite orbital parameters, location coordinates of cell center and the radius of cell coverage. |
| [R2-2210353](file:///C:\Data\3GPP\Extracts\R2-2210353%20Further%20view%20on%20Idle-%20and%20Connected-mode%20NTN%20mobility%20in%20Rel-18.docx) | Proposal 1: UE performs individual estimation, considering satellite’s ephemeris, cell reference location and its own location to enable location-based reselections in Earth-moving scenario. |
| [R2-2210468](file:///C:\RAN2%20work\RAN2-119bis%202210\tdoc\R2-2210468-8.7.4-cell-reselection-enhancement.docx) | Proposal 4: If the serving cell is an earth-moving cell, NW provides assistance information for UE to estimate the serving cell movement for location-based cell reselection measurement. |
| [R2-2210737](file:///C:\RAN2%20work\RAN2-119bis%202210\tdoc\R2-2210737-Discussion-on-idle-mode-aspects-for-NTN.docx) | Proposal 5 Multiple reference locations and its time information should be broadcasted to provide time-variant reference location of earth moving cell. |
| R2-2210090 | Proposal 1 RAN2 to discuss the following options on location-based measurement initiation for earth moving cell:  - Option 1: A new distance threshold for the distance between UE and the serving satellite, i.e., service link distance.  - Option 2: Rel-17 distance threshold with the cell reference location determination based on the sub-satellite point (derived by satellite ephemeris) and the broadcasted location offset between sub-satellite point and the cell reference location. |

Based on above proposals, in Earth-moving cell UE is able to estimate the movement of cell coverage according to assistance information provided by network. As UE location is also known by UE, then UE can tell when serving cell stops providing coverage at the present UE location.

Regarding the assistance information provided by network,

1. satellite orbital parameters. Ephemeris data (one type is for satellite orbital parameters, the other type is for instantaneous position and velocity of satellite) is already included in SIB19. And for prediction of movement of cell coverage, satellite orbital parameters should be provided.

2. the location of cell center. Similarly, the reference location has been specified for Quasi-Earth-fixed cell, and it can also be provided in Earth-moving cell. Another alternative is to provide “Multiple reference locations and its time information”, instead of updating the value every time along with the cell movement.

3. the radius of cell coverage. Similarly, the distance threshold have been specified for Quasi-Earth-fixed cell, and it can also be provided in Earth-moving cell.

**Question 1: Regarding the assistance information of serving cell for UE to estimate when the serving cell stops providing coverage at the present UE location, whether the following parameters should be provided by network** **in Earth-moving cell:**

1. **satellite orbital parameters, not instantaneous position and velocity of satellite**
2. **location coordinates of cell center, or in other term, cell reference location**
3. **the radius of cell coverage, or in other term, a distance threshold**
4. **a distance threshold between UE and satellite**

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| **Company** | **Y or N** | **Additional comments** |
| Transsion Holdings | Y but | satellite orbital parameters:  Regarding there was introduced SIB19 to broadcast ephemeris information, position and velocity of satellite, in Rel-17. RAN2 can reuse it for moving cell and there is no need to provide extra satellite orbital parameters.  the location of cell center:  For quasi-earth fixed cell, it will broadcast reference point that indicate the cell center, which should be included for moving cell as well, it can assist UE to estimate how far it’s away from cell center and perform cell reselection evaluation.  the radius of cell coverage:  It can be provided as one part of cell reselection parameters. Based on Rel-17, quasi-earth fixed cell, it had introduce a distance threshold to assist UE to decide whether to perform neighbor cell measurement. In Rel-18, RAN2 can follow the same method for UE measurement enhancement. |
| Samsung | Y 1-3 with comment | For 2 and 3, prefer to use cell reference location and distance threshold, which may or may not be the cell center and the cell radius, respectively, and can be up to NW configuration, similar to the Rel-17 reference location and distance threshold for cell reselection.  For 2, the time stamp for the provided reference location coordinates is also needed. FFS whether ephemeris epoch time can be used or not.  In addition, in the case that the serving cell’s coverage (i.e. satellite beam footprints) is moving relatively static with respect to the satellite’s nadir movement, the UE can estimate the movement of the cell coverage based on serving satellite ephemeris and the reference location with a time stamp. But the UE needs to know the serving cell is an earth moving cell. So in this case, the cell type indication should be provided.  In another case, if the serving cell’s coverage (i.e. satellite beam footprints) is not moving relatively static with respect to the satellite’s nadir movement, the UE cannot estimate the movement of cell coverage only based on the serving satellite ephemeris. In this case, the velocity of the reference location (i.e., moving speed and direction) needs to be provided so that the UE can estimate the trajectory of the reference location. |
| OPPO | Yes (1/2/3 or 1/4, 1 is already supported in legacy) | For earth moving cell, reference location is always time-varying with the movement of satellite, therefore broadcasting cell reference location is not a viable solution.  An obvious approach is to use the distance between UE and the serving satellite, i.e., the service link distance to estimate when the serving cell stops providing coverage at the present UE location. Hence, the parameters 1/4 could be considered to provide by network in earth moving cell.  Alternatively, if we still prefer to reuse the distance between UE and cell reference location at ground to estimate, i.e., based on the parameters 1/2/3. Regarding how to provide the reference location at ground by network, we should consider avoiding the broadcast of time-varying parameter.  p.s. for 1, we think existing SIB19 has already provided serving cell’s satellite ephemeris and we don’t need to mention it again for Rel-18 solutions. |
| Huawei, HiSilicon | Y 1-3 | 1 and 2 are in the current spec already. |
| Lenovo | 1 already supported  Yes to 2/3 with comments | As we commented online, 1 has already been supported, but not enough.  For 2, we need to further consider how to indicate the moving cell reference location more efficiently. For example, reference location with movement information, or multiple reference locations with intervals between.  For 3, the issue is similar to 2, we need to further consider how to indicate the moving cell coverage more efficiently. |
| vivo | Yes for 2 and 3 with comments | UE cannot infer the trajectory of the cell only based on the satellite orbital parameters, as how the cell coverage is projected on the earth surface depends also on how the beams are steered and other related factors. In order to infer the movement trajectory of the earth-moving cell, a rule on how the reference location changes over time (e.g. taking the reference location as a function of time) needs to be known by the UE for calculating the real-time reference location. Combined with cell coverage, UE can calculate when the serving cell stops providing coverage at the present UE location. This, e.g. need of 2-D reference location, is following the same logic as how/why we introduced cell reselection enhancements for the quasi-earth fixed cell case in Rel-17.  For Option 3, perhaps it is hard to say that the threshold is exactly equal to the cell radius, as the UE should start measurement for cell reselection when the serving cell’s coverage is to be lost, instead of having been lost. Also, this threshold is related to the distance between the UE and the reference location, not that apart from the satellite. |
| Apple | Yes for 2 and 3 | To provide the assistance information to describe the earth-moving cell’s coverage, NW can provide the reference location and distance threshold (in legacy way) together with the reference time. |
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**Question 2: Regarding how to provide the location coordinates of cell center by network (if it is agreed to be provided as discussed in Q1):**

**Option 1: only location coordinates of current cell center, and network is supposed to update the values every time when it is provided for Earth-moving cell.**

**Option 2:** **multiple reference locations and its time information of Earth-moving cell.**

**Option 3: based on the sub-satellite point derived by satellite ephemeris and the broadcasted location offset between sub-satellite point and the cell reference location**

**Option 4: cell type (fixed or moving), reference location coordinates with a time stamp, and the velocity of reference location**

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| **Company** | **Option 1 or 2 or 3 or 4** | **Additional comments** |
| Transsion Holdings | **Option 2** with comments | Extra reference points can be provided to UE for cell reselection enhancement. Regarding moving cell, UEs are relative static and they may measure for upcoming cell of the same orbital. This extra reference point can be design close to the upcoming cell, for UEs are close to the extra reference point can start performing measurement or the upcoming cell, else, UEs are far from the extra reference point can keep monitoring for serving cell only.  Either reference point or extra reference points, UE can use ephemeris information to estimate/calculate real-time bof them. |
| Samsung | Option 4 | In the case that the serving cell’s coverage (i.e. satellite beam footprints) is moving relatively static with respect to the satellite’s nadir movement, based on the ephemeris, the UE can also derive the trajectory of nadir and the nadir coordinates at the time stamp of reference location. Due to relative static between nadir and reference location, the UE can derive the trajectory of the reference location. So in this case, reference location coordinates with a time stamp should be provided. FFS whether ephemeris epoch time can be used or not.  In another case, if the serving cell’s coverage (i.e. satellite beam footprints) is not moving relatively static with respect to the satellite’s nadir movement, the UE cannot estimate the movement of reference location based on the nadir trajectory. In this case, the coordinates of reference location at a time stamp and the velocity of the reference location (i.e., moving speed and direction) need to be provided, so that the UE can estimate the trajectory of the reference location from the time stamp. By providing the velocity of reference location, NW does not need to frequently update the coordinates and may less frequently update the reference location coordinates with a time stamp and the velocity. |
| OPPO | Option 3 | For the earth moving cell, satellite generates fixed or non-steerable beams whose coverage area slides over the earth surface. Therefore, the reference location is time-varying.  For Option 1, as stated by Rapp, network has to update the values every time.  For Option 2, multiple reference locations and its time information would introduce additional signalling overhead on system information.  Therefore, we suggest to consider Option 3, i.e., to avoid the broadcast of time-varying parameter, the cell reference location can be determinate by a fixed location offset (e.g., in latitude and longitude) away from the sub-satellite point, where the sub-satellite point can be derived from satellite ephemeris, e.g. the intersection of the line from the Earth center to the satellite with the earth's surface.  Ideally, if the satellite generates beam that is perpendicular to the earth’s surface, the cell reference location is exactly the sub-satellite point. In this case, the location offset could be absent. |
| Huawei, HiSilicon | Other | Option 5: cell type, reference location corresponding to the *epochTime* (reuse the existing *epochTime*).  With the existing ephemeris and reference location, the UE can already predict the trajectory of the reference location. But it needs to know cell type, because no prediction is needed in quasi-fixed cells. |
| Lenovo | Option 2/3/4 | We are open to discuss each one to find a solution. For 1 we think it is not useful unless we specify SI change for that, which is not acceptable considering that ephemeris change will neither trigger SI change. |
| vivo | See comments | We prefer that a rule on how the reference location changes over time (e.g. taking the reference location as a function of time) can be provided, and then the UE can calculate real-time reference location based on the rule and the current time. |
| Apple | Option 2/4 | NW can provide the reference (time+ location) info. To reduce the signalling overhead, the reference points that the network may provide will not be particularly dense.  To help UE know the cell coverage in real-time, NW also needs to provide UE with the velocity info of the satellite. |
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As for how to provide this assistance information, the following proposal is made.

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| Tdoc | Proposals |
| [R2-2210353](file:///C:\Data\3GPP\Extracts\R2-2210353%20Further%20view%20on%20Idle-%20and%20Connected-mode%20NTN%20mobility%20in%20Rel-18.docx) | Proposal 3: System information is the basic means for providing necessary parameters to assist the NTN UE in intra-NTN cell reselection process. |

Considering the outcome of Q1 and Q2, the proposal is updated to be more specific as below:

Proposal: System information is the basic means for providing necessary parameters to assist UE to estimate when the serving cell stops providing coverage at the present UE location.

**Question 3: whether the following proposal is agreeable:**

**Proposal: System information is the basic means for providing necessary parameters to assist UE to estimate when the serving cell stops providing coverage at the present UE location.**

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| **Company** | **Y or N** | **Additional comments** |
| Transsion Holdings | Y |  |
| Samsung | Y |  |
| OPPO | Y | We are fine in principle regarding system information is used to provide necessary parameters, but the broadcast of time-varying parameter needs to be avoiding. |
| Huawei, HiSilicon | Y |  |
| Lenovo | Y |  |
| vivo | Yes |  |
| Apple | Y |  |
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### 2.1.2 Assistance information of neighbour cell for UE to estimate when the neighbour cell starts providing coverage at the present UE location

According to the following proposal, if a UE is able to estimate when the serving cell stops providing coverage at the present UE location, it can also estimate when the neighbour cell starts providing coverage at the present UE location, then it can know which neighbour cells are the next upcoming cells.

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| Tdoc | Proposals |
| [R2-2209578](file:///C:\Data\3GPP\Extracts\R2-2209578%20Discussion%20on%20NTN%20cell%20reselection%20enhancements.docx) | Proposal 3: The parameters explained in Proposal 1 can also be for neighbour cells for UE to estimate which cells are the upcoming cells for cell reselection. I.e., these parameters of the neighbour cell can be satellite orbital parameters, location coordinates of cell center and the radius of cell coverage. |

**Question 4: whether the assistance information below of a neighbour cell can be used for UE to estimate when the neighbour cell starts providing coverage at the present UE location.**

1. **satellite orbital parameters, not instantaneous position and velocity of satellite**
2. **location coordinates of cell center, or in other term, cell reference location**
3. **the radius of cell coverage, or in other term, a distance threshold**

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| **Company** | **Y or N** | **Additional comments** |
| Transsion Holdings | N |  |
| Samsung | Y with comment | Similar comment as for Q1  For 2 and 3, prefer to use cell reference location and distance threshold, which may or may not be the cell center and the cell radius, respectively, and can be up to NW configuration, similar to the Rel-17 reference location and distance threshold for cell reselection.  For 2, the time stamp for the provided reference location coordinates is also needed. FFS whether ephemeris epoch time can be used or not.  In addition, in the case that the neighbour cell’s coverage (i.e. satellite beam footprints) is moving relatively static with respect to the satellite’s nadir movement, the UE can estimate the movement of the cell coverage based on neighbour cell’s satellite ephemeris and the reference location with a time stamp. But the UE needs to know the neighbour cell is an earth moving cell. So in this case, the cell type indication should be provided.  In another case, if the neighbour cell’s coverage (i.e. satellite beam footprints) is not moving relatively static with respect to the satellite’s nadir movement, the UE cannot estimate the movement of cell coverage only based on the neighbour cell’s satellite ephemeris. In this case, the velocity of the reference location (i.e., moving speed and direction) of the neighbour cell needs to be provided so that the UE can estimate the trajectory of the reference location. |
| OPPO | Y for neighbour cell’s assistance information, FFS for exact information | Providing neighbour cell’s incoming information can be beneficial for UE to decide when to start neighbour cell’s measurement, e.g. only when neighbour cell has come, measurement can be started.  We think at least network can provide some time-based assistance information, e.g. a time threshold according to the time when some moving neighbour cells come across with the serving cell’ coverage. |
| Huawei, HiSilicon | N | It was discussed in R17 whether the assistance information of upcoming cell should be provided, and no conclusion was made. Prefer not to duplicate the discussion. |
| Lenovo | Not sure | We think it may be too early or unnecessary to discuss this for now. Only if we have agreement on idle mobility based on neighbour cell status (e.g., when it stars to serve UE area) shall we discuss what neighbour cell information to be provided. For now we should focus on what and how serving cell information to be provided. |
| vivo | See comments | The benefits of knowing when the neighbour cell starts providing coverage at the present UE location are unclear, and thus it is too early to directly discuss the related assistance information before the need/benefit is first justified. We think we should first focus on the serving cell related enhancements, taking the Rel-17 NTN introduced mechanisms as the baseline. |
| Apple | Y, 2 and 3 | The neighbour cell’s deployment will be changed. with the location of the earth-moving cell change.  Therefore, to help UE only perform the measurement on the adjacent cells, NW can provide the neighbour cells/frequencies together with the reference location info. |
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### 2.1.3 Whether a UE can relax neighbour cell measurements before the serving cell stops providing coverage at the present UE location

According to the following proposal, in order to save UE power consumption, before the serving cell stops providing coverage at the present UE location, it’s beneficial to relax neighbour cell measurements.

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| Tdoc | Proposals |
| [R2-2209578](file:///C:\Data\3GPP\Extracts\R2-2209578%20Discussion%20on%20NTN%20cell%20reselection%20enhancements.docx) | Proposal 2: If proposal 1 is agreed, to define a new trigger for the measurement relaxation considering the estimated cell stop time. For example, after UE camps in a cell, or for certain time “x”, UE may be allowed to relax neighbour cell measurements until the estimated cell stop time or certain time “y” before the estimated stop time. |

**Question 5: whether a UE is allowed to relax neighbour cell measurements** **before the serving cell stops providing coverage at the present UE location.**

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| **Company** | **Y or N** | **Additional comments** |
| Transsion Holdings | Y | For moving cell scenario, UE can use assistant information and its self location information to decide whether to relax neighbour cell measurements. |
| Samsung | Y |  |
| OPPO | Left to UE implementation as in Rel-17 | Similar as Rel-17 NR NTN, we only specify that UE shall start neighbour cell’s measurement before T-service, but the exact time for starting the measurement is left to UE implementation. We don’t need to discuss the possible UE implementation, e.g. whether relax measurement or not and when to relax. |
| Huawei, HiSilicon | N | In R17, it was clarified that stop time based measurement triggering aims to guarantee the UE has already measured neighbour cell before the serving cell stops serving, rather than saving UE power.  If we go the other direction in R18, I am not sure how this co-exists with the R17 mechanism.  Besides, we already introduced relaxed monitoring for GSO in R17. |
| Lenovo | Y | OK to have the same mechanism as quasi-fixed, as long as UE can have the exact time when the serving cell stops providing coverage at the present UE location. |
| vivo | No | For quasi-fixed cell, RAN2 agreed that the exact time to start measurement before *t-Service* is up to UE implementation. We think a similar principle can be adopted for earth-moving cell, and this optimization is not needed. |
| Apple | Y |  |
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### 2.1.4 t-service in Earth-moving cell

In previous questions, the discussion point is whether UE can estimate the “t-service” itself for Earth-moving cell. According to the following proposals, it’s proposed to t-service is still provided in Earth-moving cell, e.g., only “valid for a particular location on Earth”. And the t-service update scheme should also be considered.

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| Tdoc | Proposals |
| [R2-2210353](file:///C:\Data\3GPP\Extracts\R2-2210353%20Further%20view%20on%20Idle-%20and%20Connected-mode%20NTN%20mobility%20in%20Rel-18.docx) | Proposal 2: To enable time-based reselections in Earth-moving scenario, the IDLE UE is capable of computing its own location to adjust t-Service provided in SIB19. |
| [R2-2210589](file:///C:\RAN2%20work\RAN2-119bis%202210\tdoc\R2-2210589.docx) | Proposal 4: Introduce reference location and/or t-service update scheme for cell reselection enhancements for earth moving cell |
| R2-2210090 | Proposal 2 For time-based measurement initiation for earth moving cell, RAN2 consider introducing a new time threshold T1 according to the time when the moving serving cell comes across some neighbour cells’ coverage. FFS on whether T1 is configured per UE or per frequency. |

**Question 6: if RAN2 agrees that UE is able to estimate when the serving cell stops providing coverage at the present UE location, whether t-service still needs to be provided in system information by network in Earth-moving cell.**

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| **Company** | **Y or N** | **Additional comments** |
| Transsion Holdings | N | UE use distance-based or location-based is sufficient. |
| Samsung | N | UE can estimate the movement of cell coverage based on the provided parameters. t-Service for earth moving cell is not needed. |
| OPPO | N | For serving cell-relevant triggering condition, we propose RAN2 to prioritize discussion on location-based trigger which is more straightforward for earth moving cells. Stop time at UE’s present location would be difficult to determine, which can be treated as a low priority. |
| Huawei, HiSilicon | N | It is not feasible to provide t-Service for moving cells, because the exact value is different for UEs located at different places. |
| Lenovo | Maybe | If UE predicts the exact time when the serving cell stops providing coverage at the present UE location, then we do not need t-Service to indicate. However, t-Service may have other use e.g., as the feeder link switch time. |
| vivo | Yes | The UE-autonomously estimated stop time is the time caused by service link switch, but the UE cannot estimate the time of feeder link switch which is only known at the NW side. One cannot assume that feeder link switch never happens in the earth-moving cell case.  Considering the time of feeder link switch is common for all UEs in the cell, handling of the stop time caused by the feeder-link switch in earth moving cell may follow a similar mechanism specified in Rel-17, i.e. a configured *t-Service* with related procedure in TS 38.304. |
| Apple | N | For the earth-moving cell, the t-service configuration is not so effective as in the fix cell, since each UE needs to update and maintain the ToS time according to the satellite’s velocity and location changes.  Therefore, the location-based method is sufficient. |
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## 2.2 NTN-TN cell reselection

During the online discussion in first week, the following agreement was achieved:

Agreements:

1. To enhance NTN-TN cell reselection, means are defined for a UE to differentiate when camping in an area only covered by NTN network (earth-moving or earth-fixed) vs an area where TN network(s) is/are also available.

### 2.2.1 Cell type (i.e. “TN” vs “NTN”)

Regarding the cell type (i.e. “TN” vs “NTN”), it is proposed that it should be indicated explicitly for a neighbour cell in some proposals below. And there is also one proposal to mention that “a UE can distinguish whether a neighbor cell or frequency belongs to a terrestrial or non-terrestrial network via existing specification”, e.g., “based on the ARFCN of the neighbouring carrier”.

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| Tdoc | Proposals |
| [R2-2209578](file:///C:\Data\3GPP\Extracts\R2-2209578%20Discussion%20on%20NTN%20cell%20reselection%20enhancements.docx) | Proposal 4.1. If proposal 4 is agreed,” cell type" (i.e. “TN” vs “NTN”) of a neighbour cell is indicated to UE (e.g. explicitly or implicitly). |
| [R2-2210217](file:///C:\RAN2%20work\RAN2-119bis%202210\tdoc\R2-2210217.docx) | Proposal 3: Serving cell’s system information include an indication that whether a neighbour cell is an NTN cell or not. |
| [R2-2210438](file:///C:\RAN2%20work\RAN2-119bis%202210\tdoc\R2-2210438--R18-NR-NTN-WI-AI-8.7.4--Idle-Inactive-enhancements.docx) | Proposal 7: RAN2 to confirm that a UE can distinguish whether a neighbor cell or frequency belongs to a terrestrial or non-terrestrial network via existing specification. |
| [R2-2210598](file:///C:\RAN2%20work\RAN2-119bis%202210\tdoc\R2-2210598.docx) | Proposal 3: We can introduce an indication to identify TN cells in the different neighbor lists. |

After further checking, Rapporteur thinks it’s not feasible to solely rely on ARFCN to distinguish TN cell from NTN cell, as there is an overlap between TN bands and NTN bands.

RAN4 has defined NTN specific band in TS 38.101-5 as below:

Table 5.2.2-1: NTN satellite bands in FR1

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| NTN satellite operating band | Uplink (UL) operating band Satellite Access Node receive / UE transmit  FUL,low – FUL,high | Downlink (DL) operating band Satellite Access Node transmit / UE receive  FDL,low – FDL,high | Duplex mode |
| n256 | 1980MHz – 2010 MHz | 2170 MHz – 2200 MHz | FDD |
| n255 | 1626.5 MHz – 1660.5 MHz | 1525 MHz – 1559 MHz | FDD |
| NOTE: NTN satellite bands are numbered in descending order from n256. | | | |

And the NTN frequency range is totally the same as (n255 and n24) or included in TN bands (n256 and n65).

Table 5.2-1: NR operating bands in FR1

|  |  |  |  |
| --- | --- | --- | --- |
| NR operating band | Uplink (UL) *operating band* BS receive / UE transmit  FUL\_low  – FUL\_high | Downlink (DL) *operating band* BS transmit / UE receive  FDL\_low – FDL\_high | Duplex Mode |
| n1 | 1920 MHz – 1980 MHz | 2110 MHz – 2170 MHz | FDD |
| n2 | 1850 MHz – 1910 MHz | 1930 MHz – 1990 MHz | FDD |
| n3 | 1710 MHz – 1785 MHz | 1805 MHz – 1880 MHz | FDD |
| n5 | 824 MHz – 849 MHz | 869 MHz – 894 MHz | FDD |
| n7 | 2500 MHz – 2570 MHz | 2620 MHz – 2690 MHz | FDD |
| n8 | 880 MHz – 915 MHz | 925 MHz – 960 MHz | FDD |
| n12 | 699 MHz – 716 MHz | 729 MHz – 746 MHz | FDD |
| n13 | 777 MHz – 787 MHz | 746 MHz – 756 MHz | FDD |
| n14 | 788 MHz – 798 MHz | 758 MHz – 768 MHz | FDD |
| n18 | 815 MHz – 830 MHz | 860 MHz – 875 MHz | FDD |
| n20 | 832 MHz – 862 MHz | 791 MHz – 821 MHz | FDD |
| n2416 | 1626.5 MHz – 1660.5 MHz | 1525 MHz – 1559 MHz | FDD |
| n25 | 1850 MHz – 1915 MHz | 1930 MHz – 1995 MHz | FDD |
| n26 | 814 MHz – 849 MHz | 859 MHz – 894 MHz | FDD |
| n28 | 703 MHz – 748 MHz | 758 MHz – 803 MHz | FDD |
| n29 | N/A | 717 MHz – 728 MHz | SDL |
| n303 | 2305 MHz – 2315 MHz | 2350 MHz – 2360 MHz | FDD |
| n34 | 2010 MHz – 2025 MHz | 2010 MHz – 2025 MHz | TDD |
| n3810 | 2570 MHz – 2620 MHz | 2570 MHz – 2620 MHz | TDD |
| n39 | 1880 MHz – 1920 MHz | 1880 MHz – 1920 MHz | TDD |
| n40 | 2300 MHz – 2400 MHz | 2300 MHz – 2400 MHz | TDD |
| n41 | 2496 MHz – 2690 MHz | 2496 MHz – 2690 MHz | TDD |
| n46 | 5150 MHz – 5925 MHz | 5150 MHz – 5925 MHz | TDD13 |
| n4711 | 5855 MHz – 5925 MHz | 5855 MHz – 5925 MHz | TDD |
| n48 | 3550 MHz – 3700 MHz | 3550 MHz – 3700 MHz | TDD |
| n50 | 1432 MHz – 1517 MHz | 1432 MHz – 1517 MHz | TDD1 |
| n51 | 1427 MHz – 1432 MHz | 1427 MHz – 1432 MHz | TDD |
| n53 | 2483.5 MHz – 2495 MHz | 2483.5 MHz – 2495 MHz | TDD |
| n65 | 1920 MHz – 2010 MHz | 2110 MHz – 2200 MHz | FDD4 |
| n66 | 1710 MHz – 1780 MHz | 2110 MHz – 2200 MHz | FDD |
| n67 | N/A | 738 MHz – 758 MHz | SDL |
| n70 | 1695 MHz – 1710 MHz | 1995 MHz – 2020 MHz | FDD |
| n71 | 663 MHz – 698 MHz | 617 MHz – 652 MHz | FDD |
| n74 | 1427 MHz – 1470 MHz | 1475 MHz – 1518 MHz | FDD |
| n75 | N/A | 1432 MHz – 1517 MHz | SDL |
| n76 | N/A | 1427 MHz – 1432 MHz | SDL |
| n7712 | 3300 MHz – 4200 MHz | 3300 MHz – 4200 MHz | TDD |
| n78 | 3300 MHz – 3800 MHz | 3300 MHz – 3800 MHz | TDD |
| n7917 | 4400 MHz – 5000 MHz | 4400 MHz – 5000 MHz | TDD |
| n80 | 1710 MHz – 1785 MHz | N/A | SUL |
| n81 | 880 MHz – 915 MHz | N/A | SUL |
| n82 | 832 MHz – 862 MHz | N/A | SUL |
| n83 | 703 MHz – 748 MHz | N/A | SUL |
| n84 | 1920 MHz – 1980 MHz | N/A | SUL |
| n85 | 698 MHz – 716 MHz | 728 MHz – 746 MHz | FDD |
| n86 | 1710 MHz – 1780 MHz | N/A | SUL |
| n89 | 824 MHz – 849 MHz | N/A | SUL |
| n90 | 2496 MHz – 2690 MHz | 2496 MHz – 2690 MHz | TDD5 |
| n91 | 832 MHz – 862 MHz | 1427 MHz – 1432 MHz | FDD9 |
| n92 | 832 MHz – 862 MHz | 1432 MHz – 1517 MHz | FDD9 |
| n93 | 880 MHz – 915 MHz | 1427 MHz – 1432 MHz | FDD9 |
| n94 | 880 MHz – 915 MHz | 1432 MHz – 1517 MHz | FDD9 |
| n958 | 2010 MHz – 2025 MHz | N/A | SUL |
| n9614 | 5925 MHz – 7125 MHz | 5925 MHz – 7125 MHz | TDD13 |
| n9715 | 2300 MHz – 2400 MHz | N/A | SUL |
| n9815 | 1880 MHz – 1920 MHz | N/A | SUL |
| n9916 | 1626.5 MHz – 1660.5 MHz | N/A | SUL |
| n100 | 874.4 MHz – 880 MHz | 919.4 MHz – 925 MHz | FDD |
| n101 | 1900 MHz – 1910 MHz | 1900 MHz – 1910 MHz | TDD |
| n10214 | 5925 MHz – 6425 MHz | 5925 MHz – 6425 MHz | TDD13 |
| n10417,18 | 6425 MHz – 7125 MHz | 6425 MHz – 7125 MHz | TDD |
| NOTE 1: UE that complies with the NR Band n50 minimum requirements in this specification shall also comply with the NR Band n51 minimum requirements.  NOTE 2: UE that complies with the NR Band n75 minimum requirements in this specification shall also comply with the NR Band n76 minimum requirements.  NOTE 3: Uplink transmission is not allowed at this band for UE with external vehicle-mounted antennas.  NOTE 4: A UE that complies with the NR Band n65 minimum requirements in this specification shall also comply with the NR Band n1 minimum requirements.  NOTE 5: Unless otherwise stated, the applicability of requirements for Band n90 is in accordance with that for Band n41; a UE supporting Band n90 shall meet the requirements for Band n41. A UE supporting Band n90 shall also support band n41.  NOTE 6: A UE that supports NR Band n66 shall receive in the entire DL operating band.  NOTE 7: A UE that supports NR Band n66 and CA operation in any CA band shall also comply with the minimum requirements specified for the DL CA configurations CA\_n66B and CA\_n66(2A) in the current version of the specification.  NOTE 8: This band is applicable in China only.  NOTE 9: Variable duplex operation does not enable dynamic variable duplex configuration by the network, and is used such that DL and UL frequency ranges are supported independently in any valid frequency range for the band.  NOTE 10: When this band is used for V2X SL service, the band is exclusively used for NR V2X in particular regions.  NOTE 11: This band is unlicensed band used for V2X service. There is no expected network deployment in this band.  NOTE 12: In the USA this band is restricted to 3450 – 3550 MHz and 3700 – 3980 MHz. In Canada this band is restricted to 3450 – 3650 MHz and 3650 – 3980 MHz.  NOTE 13: This band is restricted to operation with shared spectrum channel access as defined in 37.213.  NOTE 14: This band is applicable only in countries/regions designating this band for shared-spectrum access use subject to country-specific conditions.  NOTE 15: The requirements for this band are applicable only where no other NR or E-UTRA TDD operating band(s) are used within the frequency range of this band in the same geographical area. For scenarios where other NR or E-UTRA TDD operating band(s) are used within the frequency range of this band in the same geographical area, special co-existence requirements may apply that are not covered by the 3GPP specifications.  NOTE 16: DL operation in this band is restricted to 1526 – 1536 MHz and UL operation is restricted to 1627.5 – 1637.5 MHz and 1646.5 – 1656.5 MHz.  NOTE 17: For this band, CORESET#0 values from Table 13-5 or Table 13-6 in [8, TS 38.213] are applied regardless of the minimum channel bandwidth.  NOTE 18: [This band is applicable only to RCC countries in accordance with RCC Recommendation 1/21] | | | |

**Question 7: whether the following proposal is agreeable:**

**Proposal: add an indication of the “cell type” (i.e. “TN” vs “NTN”) of a neighbour cell in system information.**

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| **Company** | **Y or N** | **Additional comments** |
| Transsion Holdings | Y | It can help UE to identify if the neighbor cell is TN or NTN, then UE can based on assistance inform perform cell reselection enhancement respectively. |
| Samsung | Y |  |
| OPPO | Y |  |
| Huawei, HiSilicon | N | We think the UE can use band numbers to differentiate TN and NTN neighbour frequencies.  Even though there is some overlapping in the frequency range of the TN and NTN bands, but we think in real deployment, such overlapping might not happen at the same location? |
| Lenovo | Not sure | Firstly, if we define assistance information as in Q8 below, we wonder if cell type is necessary.  Secondly, does this mean a new and explicit cell type indication? Can *cellBarredNTN* be reused? |
| vivo | No | Some implicit methods can be used: for example, if a cell is associated with some newly defined assistance information (e.g., coverage information of TN cells) for power saving, UE can consider the cell as a TN cell. Something like an explicit “1-bit” indication on the “NTN vs. TN” is not needed. |
| Apple | Y | The explicit indication can make the spec more forward compatible and can avoid the dependence on the RAN4 spec and the NTN specific band number. |
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### 2.2.2 Assistance information for UE to identify an area where TN network is available

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| Tdoc | Proposals |
| [R2-2209578](file:///C:\Data\3GPP\Extracts\R2-2209578%20Discussion%20on%20NTN%20cell%20reselection%20enhancements.docx) | Proposal 4.2. If proposal 4 is agreed, network provides assistance information of NTN-only area (e.g., cell center and cell radius of TN neighbour cells and NTN serving cell, or the boundary line between TN area and NTN area). |
| [R2-2210353](file:///C:\Data\3GPP\Extracts\R2-2210353%20Further%20view%20on%20Idle-%20and%20Connected-mode%20NTN%20mobility%20in%20Rel-18.docx) | Proposal 5: RAN2 is asked to consider the method where System Information provides a location-related indication where the search for TN coverage shall be initiated. |
| R2-2209753 | Proposal 3 In NTN-TN cell reselection for high priority cells, RAN2 shall introduce a new distance threshold for measurement enhancement. |
| [R2-2210045](file:///C:\RAN2%20work\RAN2-119bis%202210\tdoc\R2-2210045_NTN_mobility.docx) | Proposal 1: Network provides reference location(s) of TN cells and a distance threshold for measurements of TN frequencies in SIB19 to assist RRC\_IDLE/RRC\_INACTIVE UE in determining whether to perform measurements of TN frequencies for cell reselection. |
| [R2-2210090](file:///C:\RAN2%20work\RAN2-119bis%202210\tdoc\R2-2210090-Discussion-on-mobility-enhancements-for-idle-and-inactive-UEs.doc) | Proposal 3 For quasi-earth fixed cells, TN coverage described by a distance range from the cell center and an angle range based on a reference direction can be broadcasted to UEs to assist the TN neighbour cell measurement initiation.  Proposal 4 RAN2 to discuss the following options for the distance/angle range:  - Option 1: Two thresholds, i.e., the minimum threshold and the maximum threshold.  - Option 2: One minimum threshold and one range, i.e. the maximum threshold can be determined based on the minimum threshold and the range. |
| [R2-2210159](file:///C:\RAN2%20work\RAN2-119bis%202210\tdoc\R2-2210159-Cell-reselection-enhancements.docx) | Proposal 6: It is proposed to provide reference location of TN neighbor cell, cell coverage radius of TN neighbor cell, relative position to the current NTN cell, etc. to help UE choose suitable TN neighbor cell. |
| [R2-2210217](file:///C:\RAN2%20work\RAN2-119bis%202210\tdoc\R2-2210217.docx) | Proposal 1: For RRC\_IDLE and RRC\_INACTIVE UEs, an indication could be included in system information to indicate NTN cell’s coverage overlaps with terrestrial TN cell’s coverage. With this indication, UE may ignore serving cell thresholds and perform TN cell measurements. |
| [R2-2210468](file:///C:\RAN2%20work\RAN2-119bis%202210\tdoc\R2-2210468-8.7.4-cell-reselection-enhancement.docx) | Proposal 3: For cell reselection in NTN-NTN and NTN-TN mobility, NW provides TN cell information according to the location within a NTN cell. |
| [R2-2210737](file:///C:\RAN2%20work\RAN2-119bis%202210\tdoc\R2-2210737-Discussion-on-idle-mode-aspects-for-NTN.docx) | Proposal 2 Introduce assistance information about an area where TN cell is not deployed and TN frequency identifier to perform reduced measurement on TN frequencies. |

Regarding the Assistance information for UE to identify an area where TN network is available, the following options are proposed based on the proposals above:

1. The cell center and cell radius of TN neighbour cells, or in other terms, the reference location and a distance threshold of TN neighbour cells
2. the boundary line between TN area and NTN area
3. For quasi-earth fixed cells, TN coverage is described by a distance range from the cell center and an angle range based on a reference direction
4. an indication could be included in system information to indicate NTN cell’s coverage overlaps with terrestrial TN cell’s coverage

**Question 8: Regarding the Assistance information for UE to identify an area where TN network is available, which option(s) is agreeable:**

1. The cell center and cell radius of TN neighbour cells, or in other terms, the reference location and a distance threshold of TN neighbour cells
2. The boundary line between TN area and NTN area
3. For quasi-earth fixed cells, TN coverage is described by a distance range from the cell center and an angle range based on a reference direction
4. An indication could be included in system information to indicate NTN cell’s coverage overlaps with terrestrial TN cell’s coverage
5. NTN cell can be divided to several virtual areas based on certain criteria. The virtual areas and the corresponding TN frequency information are broadcast as assistance information to help UE perform more accurate TN measurements.

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| **Company** | **option 1/2/3/4** | **Additional comments** |
| Transsion Holdings | Option 1 |  |
| Samsung | See comment | Agree to use reference location and a distance threshold in Option 1, but the reference location can be a location inside or outside the NTN/TN cell. Broadcast cell center and cell radius of TN cells in SI may cause security issue. |
| OPPO | Option 3 | We prefer to use the assistance information based on the cell reference location of NTN cell for quasi-earth fixed cell. i.e., for quasi-earth fixed cells, the detailed coverage information can be one or more coverage areas described by a distance range from the NTN cell center and an angle range based on a reference direction. |
| Huawei, HiSilicon | Option 5 |  |
| Lenovo | Option 1 with comments | For option 1 we share Samsung’s view that the actual TN cell center shall not be indicated, and reference location of TN areas can be used instead.  For Option 2 we wonder the format and signalling overhead of indicating the line.  For Option 3 it does work for quasi-fixed cells, but we think it is better to have a unified solution.  For Option 4 we think the granularity is too coarse to have actual benefits.  For 5 we think it could be complicated if serving NTN cell is earth-moving. |
| vivo | Option 1 | We think option 1 is simpler. More generally, the reference location can even be configured as a location within the TN coverage (i.e. not necessarily within only one TN cell). With how such reference location configured being up to NW implementation, Option 1 can also work in this way. |
| Apple | Option 1 | to help UE only perform the measurement on the adjacent cells, NW can provide the neighbour cells/frequencies together with the reference location info.  NW can provide the deployment of the adjacent neighbor TN cell based on the reference location/distance in the NTN cell. And UE can based on the reference location info estimate whether to enable the neigbhor cell measurement or cell reselection to the TN neighbor cell. |
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### 2.2.3 UE measurement related behaviour in an area where TN network is not available

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| Tdoc | Proposals |
| [R2-2209578](file:///C:\Data\3GPP\Extracts\R2-2209578%20Discussion%20on%20NTN%20cell%20reselection%20enhancements.docx) | If proposal 4 is agreed, when a UE is in NTN only area, UE is not required to perform neighbour cell measurements for TN neighbour cells. |
| [R2-2210045](file:///C:\RAN2%20work\RAN2-119bis%202210\tdoc\R2-2210045_NTN_mobility.docx) | Proposal 2: If reference location(s) of TN cells and a distance threshold for measurements of TN frequencies are provided in SIB19, and if the distance between UE and any of the reference location(s) of TN cells is longer than the distance threshold, UE is not required to perform measurements of TN frequencies for inter-frequency cell reselection. |
| [R2-2210217](file:///C:\RAN2%20work\RAN2-119bis%202210\tdoc\R2-2210217.docx) | Proposal 2: The assistance information could be a distance threshold to a reference location. If UE moves beyond that threshold then it will start performing TN measurement. |
| [R2-2210737](file:///C:\RAN2%20work\RAN2-119bis%202210\tdoc\R2-2210737-Discussion-on-idle-mode-aspects-for-NTN.docx) | Proposal 1 The UE performs measurement on TN frequencies where it can find available TN cells. |

According to the proposals above, UE is not required to perform neighbour cell measurements for TN neighbour cells, when there is no TN network coverage.

**Question 9: whether the following proposal is agreeable:**

**Proposal: UE is not required to perform neighbour cell measurements for TN neighbour cells in an area where there is no TN network coverage.**

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| **Company** | **Y or N** | **Additional comments** |
| Transsion Holdings | Y |  |
| Samsung | Y |  |
| OPPO | Y | It is straightforward if the assistance information on TN coverage could be provided to UE. |
| Huawei, HiSilicon | Y |  |
| Lenovo | Y |  |
| vivo | Yes |  |
| Apple | Y |  |
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### 2.2.4 Detection of NTN coverage

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| Tdoc | Proposals |
| [R2-2210353](file:///C:\Data\3GPP\Extracts\R2-2210353%20Further%20view%20on%20Idle-%20and%20Connected-mode%20NTN%20mobility%20in%20Rel-18.docx) | **Proposal 4: RAN2 is asked to consider the method of detecting the transmission energy or SIB presence to determine the NTN coverage.** |

In R2-2210353, one enhancement is proposed that it would be beneficial to start searching for NTN cells only when needed, e.g., UE is about to move out from TN coverage. And the corresponding method could be detecting the transmission energy or SIB presence to determine the NTN coverage.

**Question 10: whether to consider the method of detecting the transmission energy or SIB presence to determine the NTN coverage when a UE currently camps on a TN cell?**

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| **Company** | **Y or N** | **Additional comments** |
| Transsion Holdings | N |  |
| Samsung | N | If the neighbor cell type (TN or NTN) is indicated in serving cell SI, UE can know directly whether it’s near NTN coverage. |
| OPPO | N | If Q7 is agreed, no need to discuss this question. |
| Huawei, HiSilicon | N |  |
| Lenovo | N |  |
| vivo | No | The coverage area of TN is much smaller than that of NTN, and thus the neighbour frequency/cell broadcast by the network can almost be detected by UE and the problem of power consumption is not as serious as camping in an NTN cell. So we think the existing mechanism of neighbour cell measurement in TN cell is sufficient. |
| Apple | N | The method requires UE to acquire the neighbour cell’s SIB before camping there, which increases the UE complexity. |
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# Conclusion