**3GPP TSG RAN WG2#121bis-e R2-23xxxx**

**e-Meeting, 17th April – 26th April 2023**

**Source: ZTE Corporation, Sanechips**

**Title: [Post121][106][NR NTN enh] NTN-NTN cell reselection (ZTE)**

**Agenda item:** **8.7.4.1.2**

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

# Introduction

This document is intended continue the discussion on NTN-NTN cell reselection open issues as per the following email discussion guidelines:

* [POST121][106][NR NTN Enh] NTN-NTN cell reselection (ZTE)

Scope: Continue the discussion on NTN-NTN cell reselection aspects (triggers for measurements, derivation of trajectory of serving cell reference location, cell reselection criteria enhancements, etc.)

Intended outcome: report of the email discussion

Deadline: Long

Please note the following deadlines:

* Deadline for companies' feedback:  **Friday 2023-03-31 12:00 UTC**

Companies providing input to this email discussion are requested to leave contact information below.

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| --- | --- | --- |
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# Discussion

In RAN2#121 NTN-NTN cell reselection open issues were discussed in offline [At121][104] with summary report in [1] to summarized companies’ views in cell reselection trigger, criteria and etc. Some of the proposals were discussed with no conclusions while some of them were not discussed due to limited time. For both cases, the proposals will be continued to discussed in this post-meeting email discussion.

## Trigger for measurements

### Location based trigger

The following agreements have been made on RAN2#121:

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| Agreements 1st online  1.In R18, for earth-moving system, satellite with steerable beam is not considered as part of mobility enhancement in NTN.  2.A serving cell reference location and a distance threshold/radius will be broadcast for earth-moving cell. FFS on whether the R17 IEs are reused or not. FFS on whether additional information needs to be broadcast to inform the UE how the reference location moves over time or if this can be derived from other information (e.g. Epoch time and ephemeris).  3.For cell selection/reselection, location-based measurement initiation is supported in earth-moving cell |
| Agreements 2nd online  1.For earth-moving cell, the location-based cell measurement rules of quasi-fixed cell is reused, i.e., for cell reselection in earth-moving cell, UE initiates measurements when its location to serving cell reference location is larger than the configured distance threshold. |

During discussion offline in [At121][104] below proposals are summarized in [1] based on companies views:

**P1: For earth-moving cell with fixed beam, the trajectory of serving cell reference location can be derived by UE based on satellite’s ephemeris and ephochTime.  (19/28)**

**P2. If confirmed UE can derive the trajectory of serving cell reference location based on satellite’s ephemeris and epochTime, no additional assisting information is needed.**

**P3: For earth-moving cell, new IE is introduced to indicate the reference location of serving cell. (19/26)**

**P5: For cell (re)selection in earth-moving system, a distance threshold is introduced for location-based measurement initiation, which reuses distanceThresh in SIB19. (16/26)**

Above proposals intends to address two ffs as highlighted in the agreements:

* FFS on whether additional information needs to be broadcast to inform the UE how the reference location moves over time or if this can be derived from other information (e.g. Epoch time and ephemeris).
* FFS on whether the R17 IEs are reused or not.

As for the first ffs, according to the summary report of [At121][104], 19 out of 28 companies support to P1, while below concerns were observed from objecting camp:

* The trajectory of satellite represented by ephemeris is an ellipse which is not parallel to the earth. There is still relative motion between reference location and satellite due to their different trajectories.
* Concerns on accuracy and would like to check with RAN1/4
* If ephemeris is provided by PVT parameters, we are not sure the UE can derive the trajectory of satellite or the ground track of sub-satellite point.

Regarding companies’ concerns on PVT format might not be sufficient to derive satellites’ orbit information, Rapporteur notice that in RAN1’s contribution in [2], two references [3][4] have provided to give example algorithm used to transfer the two formats into each other. However, rapporteur does consider discussing the format is out of RAN2 scope, therefore consult to RAN1 might be needed.

In addition, there are also questions on whether UE estimated RP location can fulfil the accuracy requirement defined by RAN4, and would like to consult RAN4.

To address companies’ concern while still respect the majorities’ views, original P1 is modified as below to indicate that is only RAN2 understanding. Question on LS to other working groups is also provided to collect companies views in later section.

**Modified Proposal: RAN2 understands for earth-moving cell, the trajectory of serving cell reference location can be derived by UE based on satellite’s ephemeris and epochTime.**

**Question 1.1) Do companies indicate whether agree on above modified proposal, and provide comments if any.**

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| **Company** | **Yes/No** | **Comments** |
| CATT | See the comment | We think that the serving cell reference location can be derived by satellite’s ephemeris and epochTime, but with additional information. With using the satellite’s ephemeris and epochTime, only the trajectory of cell whose reference location coinciden with the sub-satellite point can be derived. But for the satellite with multiple beams (usual case), the reference location of other cells, whoes reference locations are not the sub-satellite point, couldn’t be derived directly only based on the ephemeris and epochTime.  Hence, we think additional information is needed to derive the reference location for these cells. The additional information could be a reference location relative to sub-satellite point (a in the figure) or a antenna angle (b in the figure) of the serving cell. |
| MediaTek | Yes | UE can estimate (derive) it using satellite’s ephemeris and epochTime. |
| Lenovo | See comments | Firstly, we share CATT’s view that only ephemeris and epochTime are not sufficient and additional information is needed.  Secondly, we also have other concerns on deriving movement of cell reference location solely relying on ephemeris. The trajectory of satellite represented by ephemeris is an ellipse which is not parallel to the earth, meaning that the velocity of satellite does not equal to the velocity of its projection (e.g., cell reference location) on earth. The elevation angle between the reference location and the satellite, which is not part of ephemeris, also affects the velocity of the velocity of the cell reference location.  In either case mentioned above, additional information beside ephemeris and epochTime is needed. |
| Xiaomi | Yes | But for the satellite with multiple beams, the beam direction may be needed as CATT explained. |
| Huawei, HiSilicon | Yes | We think the prediction of reference location trajectory does not need to meet a very high accuracy. The reference location is mainly for measurement initiation, the NW has the flexibility to set a loose threshold that matches the aforementioned prediction accuracy, so that measurements can still be triggered timely. |
| Thalès | See the comment | As CATT explained, the ephemeris and epochTime are not enough to characterize the trajectory of the serving cell reference.  Putting aside the accuracy on the satellite velocity since the ephemeris is an ellipsis, the beam trajectory in a multi-beam system depends also on the antenna direction.  Therefore, we think additional information is needed such as angle of elevation and the azimuth angle (in a satellite referencial) for serving cell not directly upon the sub-satellite point. |
| vivo | No with comments | The sub-satellite point may be estimated based on ephemeris and *epochTime*, but since the trajectory of the satellite represented by ephemeris is an ellipse and it’s not parallel to the earth's surface, the sub-satellite point is not equal to the reference location. So UE cannot evaluate trajectory of serving cell reference location based on satellite’s ephemeris and *epochTime* (at least not possible via these two parameters only)*.* |
| TCL | See the comment | We think the serving cell reference location can be derived by satellite’s ephemeris and epochTime roughly. However we have sympathy for CATT’s or Thales’s view that in the case of multiple beams if we need more accurate reference location, additional information might be needed. |
| CAICT | Yes | We share the same view with CATT. Only ephemeris and epochTime are not enough and additional information is needed. |
| Intel | Yes with comments | Since some companies still have concern on PVT format, we could revise the proposal to “RAN2 understands for earth-moving cell, the trajectory of serving cell reference location can be derived by UE based on satellite’s ephemeris in format of orbital papameters and epochTime.” |
| OPPO | See the comment | For the concern on PVT-format ephemeris, we share the same view with Rapp. The PVT format and orbital format could be transferred to each other by the current mature algorithm, therefore we do not see the difference between these two formats.  For the concern on the derivation of sub-satellite point, i.e., the intersection of the line from the Earth center to the satellite with the earth's surface, the sub-satellite point on ground could be derived according to the satellite’s ephemeris and epoch time, which has been easily implemented for satellite system.  And we also share the same view with CATT that additional information is needed to derive the serving cell reference location based on the sub-satellite point derived by the satellite’s ephemeris and epoch time. In our understanding, the cell reference location relative to sub-satellite point would be a straightforward approach for the derivation of the trajectory of reference location. |
| Nokia | In principle yes | But we agree that it depends what kind of accuracy is essential to ensure (agree with Huawei, perhaps no extreme accuracy is needed if it is used just to initiate the measurements). This can be investigated in RAN4. |
| Qualcomm | Yes | Reference location should be associated with the center of cell, whether it consists of a single beam or multiple beams.  For UE what matters is whether it is at the cell edge (not specially beam edge if a cell consists of multiple beams).  We share similar view as Huawei, probably this is sufficient for measurement initiation purpose. |
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**Rapp summary:**

* Yes:
* No:

If company’s reply to Q1.1. is yes, please continue comments in Q1.2-1.3. If company’s reply to Q1.1. is not, please provide comments in Q1.4.

Since below proposals in offline [At121][104] is relevant to P1, If reply to Q1.1 is yes, then companies are invited to indicate which of above proposals are agreeable, and indicate comments if any.

**P2. If confirmed UE can derive the trajectory of serving cell reference location based on satellite’s ephemeris and epochTime, no additional assisting information is needed.**

**P3: For earth-moving cell, new IE is introduced to indicate the reference location of serving cell. (19/26)**

**P5: For cell (re)selection in earth-moving system, a distance threshold is introduced for location-based measurement initiation, which reuses distanceThresh in SIB19. (16/26)**

**Question 1.2) Companies are invited to indicate which of above proposals are agreeable, and provide comments if any.**

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| **Company** | **Agreeable proposals (P2/3/5)** | **Comments** |
| CATT | Disagree P2  Agree P3 P5 | For P2, additional information is needed, the additional information could be a reference location relative to sub-satellite point (a in the figure) or a antenna angle (b in the figure) of the serving cell. See our comments in Q1.1.  For P3, we prefer to introduce a new IE for the reference location of earth moving cells, so that the cell type can be differentiated. The reference location can be in form of a relative location relative to sub-satellite point.  A question to rapporteur:  For P2, we try to understand the rapporteur’s intention. Does the rapporteur means that the network provides the serving cell’s reference location (X0,Y0), and the reference location is set as the location at epochTime, then the UE can calculated the relative location (ΔX,ΔY) between the serving cell’s reference location and the sub-satellite point at that time. In the following time, UE can calculate the real-time serving cell’s reference location (Xn,Yn) by the relative location (ΔX,ΔY) and the sub-satellite point (XS,YS) (derived from ephemeris), i.e. Xn =△X+XS, Yn =△Y+YS?  If yes, in our view, the reference location at epochTime is only used to calculated relative location relative to sub-satellite point, it is more direct to provide UE the relative location between the serving cell’s reference location and the sub-satellite point, i.e. provide the (ΔX,ΔY) to UE, to avoid a complex calculation procedure. |
| MediaTek | P2, P3, P5 |  |
| Lenovo | Disagree P2  Agree P3, P5 | Same as comments to P1 |
| Xiaomi | P2, P5 | In our understanding, if the UE can derive the trajectory of serving cell reference location based on the P2, the additional reference location indication is not needed. |
| Huawei, HiSilicon | P2, P3, P5 |  |
| Thalès | Disagree P2, Agree P3, P5 |  |
| vivo |  | We want to highlight again that some companies already provided solid evidence that the reference location cannot be estimated only via the ephemeris and epoch time. At the same time, discussing additional information needed on top of these two parameter to support the UE autonomous derivation method looks even more complicated than the NW based solution, e.g. validity timer based solution, multiple reference location with validity time, etc. To this end, we would prefer no more pursuing the method of UE autonomous derivation based on ephemeris. |
| TCL | P3, P5 |  |
| CAICT | P3, P5 |  |
| Intel | P2, P3, P5 |  |
| OPPO | Disagree P2  Agree P5  Partly agree P3 | As mentioned in Q1, additional information is still needed.  For P3, we share the same view as CATT, and propose to have a modification for this proposal:  **P3a: For earth-moving cell, new IE is introduced to indicate the reference location of serving cell in form of a relative location relative to sub-satellite point.**  The intention of original proposal is to introduce a new IE for the absolute geographic location same as *ReferenceLocation-r17,* where the field value refers to *Ellipsoid-Point* defined in TS37.355, and the size of this IE is 48 bit.  For the relative location, the size of IE could be much less than that of the absolute geographic location, therefore the signalling overhead for broadcast could be reduced. |
| Nokia | All | P2 depends on the accuracy needed. P3 and P5 are OK (the same distanceThresh can be used, while a reference location may be cleaner with the new parameter for EMC). |
| Qualcomm | Agree P2,P3,P5 |  |
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**Rapp summary:**

If company’s reply to Q1.1. is yes, companies are invited to provide comments on the below question on whether consultant to other working groups (e.g., RAN1/4) is needed or not. And indicate the detailed questions/action needed.

**Question 1.3) Companies are invited to indicate whether LS is needed or not to other working groups, and indicate in the comments column the respect questions needed to be asked for corresponding WGs.**

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| **Company** | **RAN1**  **(Yes/No)** | **RAN4**  **(Yes/No)** | **Comments** |
| CATT | No | No | The location-based measurement initiation is a rough mechanism for UE to judge when to initiate the neighbour cell measurement, that high accuracy is not needed. The relative motion between reference location and satellite due to their different trajectories could be acceptable for UE to determine whether to trigger the neighbour cell measurement. We don’t need to send LS to RAN1 or RAN4 to ask evaluation on that. |
| MediaTek | No | No | We don’t need to send LS to RAN1 or RAN4 |
| Lenovo | No | No | No need for now |
| Xiaomi | No | No |  |
| Huawei, HiSilicon | No | No |  |
| Thalès | No | No |  |
| vivo | No | No |  |
| TCL | No | No |  |
| CAICT | No | No |  |
| Intel | Yes | No | We can check with RAN1 if “it’s possible to transfer the two formats of ephemeris date into each other”, and how it works. |
| OPPO | No | No |  |
| Nokia | Not needed | Possibly later | We can ask RAN4 about expected accuracy, but that is not essential now.  If RAN1 works on the algorithm for deriving reference location and if RAN1 reaches conclusions, they can inform us (no need to send the question now). |
| Qualcomm |  |  | We are ok to wait and see. |
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**Rapp summary:**

* RAN1:
* RAN4:

If reply to Q1.1. is not, please indicate in below question the methods and required information needed to inform the UE how the reference location moves over time.

**Question 1.4) If reply to Q1.1 is not, please provide in below comments column the method and required information to inform the UE how the reference location moves over time.**

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| --- | --- |
| **Company** | **Comments** |
| CATT | As we comment in Q1.1, the additional information could be a reference location relative to sub-satellite point or a antenna angle of the serving cell is needed. |
| Lenovo | Same as comments to P1, additional information beside ephemeris and epochTime is needed. |
| Thalès | Same as comment in P1, we think it is needed to add direction to the beam in the satellite referencial (axis defined by the satellite velocity and the earth center). For instance with 2 angles, one for antenna azimuth and elevation. |
| vivo | A series of reference location values can be provided by the network, and each of them is associated with the validity time (e.g. time stamp) that it applies. The UE determines the valid reference location based on the current time. |
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**Rapp summary:**

### Time-based trigger

Time-based measurement trigger for neighboring cell measurements was discussed in offline [At121][104], and there are 19 out 24 companies responds that time based trigger to address the feeder link switch case, therefore below proposal was made to address majorities views:

**P6: For cell (re)selection in earth-moving system, time-based measurement initiation is used to address feeder-link switch case. (19/24)**

Among which there are comments that this approach only needed for soft feederlink switch since for hard switch there will be service interruption, no need to trigger UE to perform measurement during the interruption time. Rapporteur tends to agree that the comment is valid.

Based on above information, companies are invited to provide comments to below question:

**Question 1.5) Companies are kindly asked to indicate whether to agree on P6. If do, please indicate whether soft/hard feeder link switch or both will be considered. Comments are welcome.**

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| --- | --- | --- | --- |
| **Company** | **Agree /Disagree** | **Soft / hard feeder link switch or both** | **Comments** |
| CATT | Agree | Both | The time-based trigger is to remind UE the current cell is going to stop serving and the UE needs to find a new cell to camp on. No matter it is seving link switch or feedlink switch, no matter the feeder link switch is soft or hard, it both means the current serving cell will stop serving at a certain time, the UE should initiate neighbour cell measurement before the cell stop serving the UE.  Additionally, for the interruption time issue of hard feeder link switch case, except the upcoming cell served by the current satellite, there may be some other cells which are covering the area. So the measurement can also be triggered. |
| MediaTek | Agree | Soft switch | Hard feedrlink switch will incur service interruption. |
| Lenovo | Agree | Both |  |
| Xiaomi | Agree | Both |  |
| Huawei, HiSilicon | Agree | Both |  |
| Thalès | Agree | Both |  |
| vivo | See comments | Both | Besides feeder-link switch case, time-based measurement initiation can be also used to address service-link switch case. In such a case, UE should evaluate the stopping time of the serving cell.  Time-based measurement initiation is used to help UE trigger measurement for cell reselection regardless of the type of feeder-link switch. For hard feeder-link switch case, on the one hand, there may be other cells that can be reselected by UE during the period between the stop time of the serving cell and the start time of the upcoming cell served by the current satellite; on the other hand, even if there is no other neighbor cell than the upcoming cell, the NW can avoid the unnecessary measurement during the interruption time, e.g., UE shall perform neighbor cell measurement before time T; the network can configure T to be sometime after the arrival of the upcoming cell served by the current satellite. |
| CAICT | Agree | Both |  |
| Intel | Agree | Soft switch | In case of hard feeder link switch, UE already needs to perform measurements on neighbour cells when current serving cell can’t be detected. |
| OPPO | Agree with comment | Both | Firstly we agree the feeder link switch is one of the use cases for time-based measurement initiation.  Furthermore, we think there is another use case which can also apply the time-based solution, i.e., we can introduce a new time threshold T1 according to the time when the moving serving cell comes across some neighbour cells’ coverage. After T1, UE should start the neighbour cell measurements. These neighbour cells can be earth-fixed cells, earth moving cells of other orbits, and TN cell, which is up to network deployment. |
| Nokia | See comments | See comments | Not sure why this case is brought in R18 and is specific to EMC? |
| Qualcomm | Agree | Both |  |
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**Rapp summary:**

**Key comments:**

## Cell reselection criteria

Based on companies’ inputs in offline [At121][104], below proposals are made in summary report[1]:

**P7: RAN2 further discuss whether to support location-based cell reselection criteria. (support: 12, not support: 11)**

**P8: Time-based cell reselection criteria is not pursued in R18. (support: 8, not support:15 )**

**Question 2.1) Companies are kindly asked to indicate which above proposals are agreeable, and provide comments if any**

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| --- | --- | --- | --- |
| **Company** | **P7**  **(Agree/Disagree)** | **P8**  **(Agree/Disagree)** | **Comments** |
| CATT | Disagree | Agree | We think the current R criterion is enough, additional location-based mechanism makes the cell reselection procedure more complex but bring no obvious benefits. |
| MediaTek | Disagree | Agree | Location and time-based cell reselection is not needed. Measurement initiation based on these information should be enough. Current R criterion is enough for cell reselection. |
| Lenovo | Disagree | Agree | Location-based cell reselection criteria introduces much calculations for multiple distances (and maybe updates) but the benefit is not clear. |
| Xiaomi | Disagree | Agree | In Rel-17, we had sufficient discussions on the location-based and time-based cell reselection criteria and the conclusion was not to introduce it, there is no need to repeat the discussions in Rel-18. |
| Huawei, HiSilicon | Disagree | Agree | Avoid repeating the similar discussions in R17. |
| vivo | Disagree | Agree | Location-based cell reselection criteria and time-based cell reselection criteria have been extensively discussed in R17, but no relevant agreements have been reached. We don't think we should spent any more time on this topic. |
| TCL | Disagree | Agree | Agree with majority. |
| CAICT | Disagree | Agree | Additional location-based mechanism make the system more complex. Legacy R criterion is enough. |
| Intel | Agree | Agree | Ok to discuss location-based cell reselection criteria, we think the intention is to avoid the measurements on some far-way neighbour cells. |
| OPPO | Agree | Agree |  |
| Nokia | Disagree | Agree | Same view we expressed in [104] – the topic was considered in R17 and not pursued. Fine to employ time or location in the decision when the UE shall measure for reselection, but then the decision to move to a new cell can be related to radio measurement, not necessarily linked to the UE’s location or time. |
| Qualcomm | Disagree | Disagree | At least, time based criteria can be considered for earth fixed cell given it has cell stop time information.  But it is better to clairify this information is needed for selecting cell among the best ranked cells. |
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**Rapp summary:**

**P7:**

* Agree:
* Disagree:

**P8**

* Agree:
* Disagree:

If agreed on P7, please provide on further comments on below question relevant to location based cell reselection criteria. As summarized in [1], below are identified candidate options for location based cell reselections:

* **Option 1: Introduce a distance threshold. Cell ranked on R-criterion first and then the distance threshold applies to down scope the candidate cells for reselection.**
  + **For cells not provided with reference location:**
    - **Alt.1: Not considered as candidate cell for reselection**
    - **Alt.2: Considered as candidate cell for reselection**
* **Option 2: Introduce a distance threshold. Distance threshold applies to decide the candidate cells and then rank the candidate cells based on R-criterion to decide the target cell for reselection.**
  + **For cells not provided with reference location:**
    - **Alt.1: Not considered as candidate cell for reselection**
    - **Alt.2: Considered as candidate cell for reselection**
* **Option 3: Cell ranked on R-criterion first and then the distance criteria applies to decide the target cell for reselection.**

**Question 2.2) Do you agreed that RAN2 further discuss location based criteria based on above three options. If do, please also indicate your preference on the option, and provide your comments if any.**

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| --- | --- | --- | --- |
| **Company** | **Agree/Disagree** | **Option 1/2/3/other** | **Comments** |
| Intel | agree | Option 2 | Alt.2 |
| OPPO | Agree | Option 3 | For both Option 1 and Option 2, we think using an absolute distance threshold to filter candidate cells is problematic because coverage of different NTN cells varies a lot. Using a small distance threshold may undesirably prevent UE from reselecting an NTN cell with large coverage. Besides, since the near-far effect in NTN is not so obvious as TN, a cell with the best RSRP may not be the most suitable cell due to the measurement accuracy issue.  For Option 3, there is no absolute distance threshold, so the issue due to the different NTN coverage does not exist. To some extent, location-based criterion plays the similar role as the legacy beam metrics (i.e., rangeToBestCell and absThreshSS-BlocksConsolidation) in form. Considering RSRP not clearly reflecting the near-far effect in NTN, we should rather consider ranking using the distance information, i.e. cell ranked on R-criterion first and then the distance criteria applies to decide the target cell for reselection. |
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**Rapp summary:**

* Option 1:
* Option 2:
* Option 3:

**Key comments:**

**Proposed proposal:**

## Others

**Question 3.1) Please provide your comments if there are any relevant issues that you consider is necessary to be discussed but is not mentioned in the questions.**

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| **Company** | **Comments** |
| Huawei, HiSilicon | We think there is room for improving the location-based measurement initiation.  In Rel-17 NTN the location-based measurement rule has been specified as follows: UE does not need to perform intra/inter-frequency measurement if serving cell is in good condition and UE is within a close distance with the reference location.  Now that UE can predict the trajectory of the satellite coverage (details FFS), for UEs located at cell edge (not satisfying the distance condition), it can still omit neighbour cell measurements if the satellite coverage is moving towards the UE. |
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**Rapp summary:**

# Conclusions

# References

1. R2-2301953 [AT121][104][NR NTN enh] NTN-NTN cell reselection (ZTE) ZTE Corporation, Sanechips discussion
2. R1-2100927 On UL time and frequency synchronization enhancements for NTN Ericsson
3. Eng, M., and René Schwarz, "Keplerian Orbit Elements → Cartesian State Vectors," available at https://downloads.rene-schwarz.com/download/M001-Keplerian\_Orbit\_Elements\_to\_Cartesian\_State\_Vectors.pdf.
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