**3GPP TSG-RAN WG2 Meeting #118-e R2-22xxxxx**

**Online, May 09 – May 20, 2022**

**Agenda item: 7.2.2**

**Source: MediaTek Inc.**

**Title: Non-Continuous Converge**

**Document for: Discussion and Decision**

# 1 Introduction

This document is aimed at discussing on the open issues, related to Discontinuous Coverage, as mentioned in RP-220943 [1] in IoT-NTN and identify potential agreements for possible convergence.

* [Post117-e][906][IoT-NTN] Non-Continuous Converge (Mediatek)

Scope: Collect comments on and progress if possible, on the Open issues related to Non-continuous coverage, see exception sheet in RP-220943.

Intended outcome: Report

Deadline: Long

**Important Dates:**

**Feedback from companies: April-22, 2022, 1:00 pm (UTC)**

**Rapporteur Summary: April-22, 2022, 11:30 pm (UTC)**

# 2 Contact

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# 3 Discussion

RAN2 agreements related to IoT NTN’s Discontinuous Coverage are mentioned in Table 1 below:

Table 1: Previous RAN2 Agreements

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| **RAN2 115-e [2]**   1. RAN2 confirms that the following will be supported: discontinuous coverage without excessive UE power consumption and without excessive failures / recovery actions. It is expected that this need to be taken into account at least for Idle mode. The requirement is applicable for all reference scenarios (GEO, MEO and LEO). 2. Satellite assistance information will be used by the UE for predicting coverage discontinuity. The details of the assistance information is FFS. FFS whether any applicable agreements made in NR-NTN can be reused. 3. The details of UEs actions when predicted to be out of coverage is FFS, e.g., stopping unnecessary cell search in the Idle mode, and FFS to what extent this need to be specified. 4. It is FFS to what extent it needs to be specified the details of UE’s prediction of discontinuous coverage and its ability to detect when it is back in coverage. 5. RAN2 sends an LS to SA2 and CT1 (cc: RAN3) for the possible alignment work in their specification due to the support of discontinuous coverage. |
| **RAN2 116-e [3]**   1. Satellite Ephemeris Parameters (not same as for L1 pre-compensation, for the constellation, not just single satellite) is needed for the UE for predicting coverage discontinuity. Other info, e.g., beam info, elevation angle, reference location or corresponding is FFS. 2. Providing the start-time of (incoming) satellite’s coverage and end-time of serving satellite’s coverage is needed for Quasi-Earth Fixed satellites. 3. From RAN2 point of view, the existing power saving mechanisms e.g., DRX, PSM, eDRX, relaxed monitoring, and WUS can be reused in IoT-NTN. Minor enhancements in existing power saving mechanisms to support discontinuous coverage is FFS. |
| **RAN2 116bis-e [4]**   1. The contents of the ephemeris / assistance info for non-continuous coverage:   Confirm that we Reuse the satellite ephemeris orbital parameters, already agreed for UL pre-compensation, for multiple satellites (Ref L1 params from R1).   1. FFS on the maximum number of satellites, whose ephemeris information will be provided. 2. FFS whether avg ephemeris (using same format as instant) + alamanc can be used (Gatehouse Proposal) 3. FFS how to signal this (new SIB for this particular purpose, dedicated signalling). 4. FFS if to introduce additional new parameters like satellite footprint reference point on ground, satellite coverage radius etc. |
| **RAN2 117-e [5]**   1. RAN2 will use a new SIB to share the ephemeris information for Discontinuous Coverage with the UEs. Sharing the information using dedicated RRC signalling is FFS. 2. While Out of Coverage in Discontinuous Coverage deployment (in Idle Mode or PSM mode) the UE is not required to perform any cell search and may deactivate its AS functions to optimize the power consumption. The remaining UE behaviour is left to UE implementation. FFS whether anything need to be specified for AS-NAS interaction. 3. For Discontinuous Coverage, ephemeris information of up to a maximum X satellites can be shared using the new SIB, where X is limited by the volume of information vs capacity of the SIB (X=4 is baseline). Increasing this maximum number by using dedicated RRC Signalling and by any further ephemeris optimization is FFS. 4. RAN2 assumes that for Discontinuous Coverage, network can signal mean ephemeris parameters (for neighbours and potentially serving satellite for coverage prediction purpose), using the same (already introduced) ephemeris format. UE can always assume these are mean values and It is up to the network implementation to derive this mean value (and any trade-off between instantaneous and mean values if needed). FFS whether additional assumptions (like averaging time) need to be clarified, e.g., to have predictable performance. 5. P3: For Prediction of discontinuous coverage, Information about satellite id, ephemeris type (FFS if two, three of four types) and epoch time will be provided with the ephemeris information. FFS if epoch time can be optional and be implicitly derived. |

The major remaining issues on discontinuous coverage, as mentioned in RP-220943 [1] are mentioned in the Table 2 below:

Table 2: Major Open Issues

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| Prediction of discontinuous coverage:   1. Address the FFS regarding signalled ephemeris type (FFS if two, three of four types and the details on semantics). 2. Address the FFS whether epoch time could be optional and be implicitly derived when not provided. 3. Address the FFS whether in addition to BCCH provide the option to share the information by dedicated RRC signalling, 4. Address the FFS whether anything need to be specified for AS-NAS interaction while the UE is out of coverage. 5. If time allows, address the open issue on an additional parameter for further enhanced spatial coverage prediction (like satellite footprint reference point on ground, satellite coverage radius) 6. Parameters for prediction of discontinuous coverage and handling of the new SIB. |

## 3.1 Ephemeris Types

In RAN2 #117-e it was agreed that for Discontinuous Coverage, network can signal mean ephemeris parameters (for neighbours and potentially serving satellite for coverage prediction purpose), using the same (already introduced) ephemeris format. UE can always assume these are mean values and It is up to the network implementation to derive this mean value (and any trade-off between instantaneous and mean values if needed). During the Come Back Session it was further agreed that for Prediction of discontinuous coverage, Information about satellite id, ephemeris type (FFS if two, three or four types) and epoch time will be provided with the ephemeris information.

As mentioned by the satellite operators, the different types of “mean orbital elements”, as mentioned in R2-2203860 [6] are listed in Table 3 below:

Table 3: Types of “mean orbital elements” with possible contents/formats

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| # | Type | Contents and format of the “orbital elements” within the SIB\_SAI | Possible propagator | Typical Validity |
| 1 | Instantaneous orbital elements  *(NOTE: This is not actually mean elements)* | **Contents:** (1) semi-major axis, (2) eccentricity, (3) argument of periapsis, (4) longitude of the ascending node, (5) inclination, (6) mean anomaly at epoch time,  **Format:** 18-byte orbital parameters format already agreed in RAN1  \* Epoch time is not transmitted. It is assumed to be the time that the SIB is received. | Propagator: Simple Keplerian motion, Two-body propagator | Order of a few hours |
| 2a | Kozai-Izsak Mean Elements | **Contents:** (1) semi-major axis, (2) eccentricity, (3) argument of periapsis, (4) longitude of the ascending node, (5) inclination, (6) mean anomaly at epoch time, (7) epoch time  **Format:** 18-byte orbital parameters format already agreed in RAN1 + 32 bit EPOCH (4 byte) **Total**: 22-bytes | J2 propagator | Order of a few days |
| 2b | Brouwer-Lyddane Mean Elements Short |
| 3 | Brouwer-Lyddane Mean Elements Long | **Contents:** (1) semi-major axis, (2) eccentricity, (3) argument of periapsis, (4) longitude of the ascending node, (5) inclination, (6) mean anomaly at epoch time, (7) epoch time  **Format:** 18-byte orbital parameters format already agreed in RAN1 + 32 bit EPOCH (4 byte)  **Total**: 22-bytes | J4 propagator   (Includes J2,J3) | Order of a few days |
| 4 | SGP4 mean elements (extracted from e.g., NORAD TLE) | **Contents:** (1) Inclination, (2) RAAN, (3) eccentricity, (4) argument of perigee, (5) mean anomaly, (6) mean motion, (7) revolution number at epoch, (8) epoch time, (9) First time derivative of the mean motion, (10) Second time derivative of the mean motion, (11) BSTAR drag term  **Format:** 18-byte orbital parameters format already agreed in RAN1 + 32 bit EPOCH + 4-bit revolution number + 33 bit ballistic coefficient + 24 bits second derivative of mean motion + 24-bit drag term = 18-byte orbital parameters + 11 byte SGP4 parameters + 4 byte EPOCH.  **Total**: 33-bytes | SGP4 propagator | Order of a few weeks |

From Table 3, it is clear that besides instantaneous orbital elements, there are four major types of mean (average) ephemeris, with three different types of formats and propagators (Note: (2a) “Kozai-Izsak Mean Elements” and (2b) “Brouwer-Lyddane Mean Elements Short” both have the same formats and propagator).

* Note that Type 1 refers to the instantaneous ephemeris, which is already defined, and is easy to implement both on UE and network side, as the instantaneous ephemeris is found from state vectors on the satellite and propagated forward by a simple Kepler propagator on the UE side.
* On the other hand, Type 4, the SGP4 format (TLE) is widely used in the satellite industry. TLEs are tracked, publicly published and are available on Celestrack. Hence, obtaining this ephemeris type is relatively easy on the network operator side. On the UE side, there are public implementations of the SGP4 propagator already available.
* For the other types (Type 2a, 2b and 3), the satellite operators may need to track their constellation in order to obtain these mean ephemerides for transmission.

As RAN2 has already agreed to support mean ephemeris information, we need to down-select at least one of the mean orbital elements, from Type 2a, Type 2b, Type 3 and Type 4 of Table 3, besides the instantaneous orbital element (Type 1).

Hence, based on this understanding the rapporteur would like to raise the following question:

**Question 1: Besides the instantaneous orbital elements (Type 1), companies are requested to down-select at least one of the mean element types from the list (Type 2a, Type 2b, Type 3, Type 4), mentioned in Table 3.**

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| --- | --- | --- |
| Company | Type 2a / Type 2b, Type 3 / Type 4 | Comments |
| GateHouse | Type 4 | SGP4 (TLE) is preferred due to its optimal validity and being widely used in the satellite industry. |
| Nokia | One type with smallest size. (i.e., either Type2a/2b or Type3) | We prefer to only have one type in Rel-17 such that network does not need to broadcast multiple formats and UE does not need to support for different types (due to different propagators used). In our understanding, dedicated RRC signalling for ephemeris should not be supported in Rel-17 (in Q3).Due to limited size of SIB for IoT, we prefer to have smallest size format in Rel-17. |
| Novamint | Type 4 preferred | Type 4 is preferred |
| Airbus | Type 4 preferred | Being most widely used and having longest validity |
| Lockheed Martin | Type 4 |  |
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**Rapporteur Summary**

<To be updated later>

## 3.2 Epoch Time

As mentioned in Table 3, except instantaneous orbital elements, all other mean ephemeris elements use epoch time as a parameter. Epoch time provides the time when mean orbital parameters where determined. As this is required for the UE to estimate the validity of the mean ephemeris, epoch time is needed and should be provided to the UE. During RAN2 117-e discussion, it was mentioned whether epoch time could be optional and if it is possible for the UE to implicitly derive the epoch time. Note that in NR-NTN 38.331 specifications, epoch time for serving satellite is included in *NTN-Config-r17,* which is shared using SIB-19.

However, for using any of the mean ephemeris elements Type 2a / Type 2b / Type 3 / Type 4, epoch time is required. This will also not introduce any additional burden on the UE for implicitly estimating the epoch time. Hence, based on this discussion, the rapporteur would like to raise the following question:

**Question 2: Do companies think that RAN2 should explicitly use the epoch for sharing the mean ephemeris elements (Type 2a/Type 2b/Type 3/Type 4) of serving satellite, as well as the neighbour satellites in IoT-NTN?**

|  |  |  |
| --- | --- | --- |
| Company | Yes / No | Comments |
| GateHouse | Yes | Indeed, as already captured in Table 3 and described in more details in <https://www.celestrak.com/NORAD/documentation/tle-fmt.php>, the “epoch time” is one of the parameters that form part of the contents of ephemeris Type 4 (SGP4/TLE). |
| Nokia | Yes | Since the information can be valid for days or even weeks, we think it may be repeated across multiple SI windows before it is updated. Explicit indication of epoch time should be supported. |
| Novamint | Yes | Epoch Time is one of the key parameters |
| Airbus | Yes | Most logical choice |
| Lockheed Martin | Yes |  |
| OPPO | Yes | As mentioned by the satellite operators in Table 3 above, the typical validity duration of the satellite ephemeris for prediction of discontinuous coverage is expected on the order of a few hours or days, even of a few weeks. Compared with the ephemeris information for accessing the serving cell in SIB31, the ephemeris information in SIB32 is expected to update unfrequently.  For implicit epoch time, epoch time is not transmitted in SIB32, and it is assumed to be the time that the SIB is received, i.e., UE uses the starting time of the DL subframe corresponding to the end of the SI window during which the SI message carrying SIB32 is transmitted. In this case, the epoch time is various for the SIB32 broadcasted in different SI window, therefore, the broadcasted six ephemeris orbital parameters are needed to update in every SI window in order to match the epoch time, even for mean orbital parameters.  Therefore, we think the explicit way needs to be supported. |
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**Rapporteur Summary**

<To be updated later>

## 3.3 Dedicated RRC Signalling for Discontinuous Coverage

During RAN2 117-e, it was briefly discussed whether in addition to BCCH, network can use dedicated RRC signalling to provide (share) the ephemeris information, required for discontinuous coverage. There are some perceived benefits of using dedicated RRC signalling, not only for future updates, but also for reducing SIB size. However, given that this is the last RAN2 meeting in Rel-17, the rapporteur thinks it will be extremely challenging to define a new dedicated RRC signalling for supporting discontinuous coverage and this could be deferred to next release (Rel-18). Hence, based on this information, the rapporteur would like to ask the following question:

**Question 3: Do companies agree that using dedicated RRC signalling to share neighbour satellites’ ephemeris information (required for discontinuous coverage), can be deferred to the next release, i.e., Rel-18?**

|  |  |  |
| --- | --- | --- |
| Company | Agree / Disagree | Comments |
| GateHouse | Agree |  |
| Nokia | Agree | Agree with Rapporteur. Dedicated RRC signaling would require UEs to become RRC Connected more frequently than they actually need based on their traffic to acquire new ephemeris. How to support dedicated RRC can be discussed in later release. |
| Novamint | Agree |  |
| Airbus | Agree |  |
| Lockheed Martin | Agree |  |
| OPPO | Agree |  |
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**Rapporteur Summary**

<To be updated later>

## 3.4 AS-NAS Interaction

In RAN2 117-e, it was agreed that while out of coverage in Discontinuous Coverage deployment (in Idle Mode or PSM mode) the UE is not required to perform any cell search and may deactivate its AS functions to optimize the power consumption. The remaining UE behaviour is left to the UE implementation. FFS whether anything need to be specified for AS-NAS interaction.

However, given that this is the last RAN2 meeting in Rel-17, the rapporteur thinks there will be no time left to discuss and specify any further regarding AS-NAS interaction in this release. Thus, the rapporteur would like to ask the following question:

**Question 4: Do the companies agree that any further details of AS-NAS interaction can be deferred to the next release (Rel-18)?**

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| --- | --- | --- |
| Company | Agree / Disagree | Comments |
| GateHouse | Agree |  |
| Nokia | Agree | We understand it is UE implementation to decide the AS-NAS interaction. If there is anything need to be specified, it should be discussed in later release. |
| Novamint | Agree |  |
| Airbus | Agree |  |
| Lockheed Martin | Agree |  |
| OPPO | Agree |  |
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**Rapporteur Summary**

<To be updated later>

## 3.5 Additional Parameter for Discontinuous Coverage

During the last RAN2 meeting, i.e., RAN2 117e, most of the companies agreed that RAN2 can include some additional, simple, new parameter(s) without any RAN1 involvement. However, regarding the details of additional parameters, the companies’ opinions and suggestions are widely varied.

* While some companies have mentioned satellite coverage radius for earth-moving beams, most of the satellite operators indicated that coverage radius is of limited use for moving cells.
* Some companies have also mentioned about the satellite footprint or reference location, especially for earth-fixed cells.
* On the other hand, satellite vendors and operators have mentioned about having minimum elevation angle as additional information, besides satellite id, ephemeris type, and ephemeris elements.

Hence, based on this discussion the only remaining new parameters that could be introduced for discontinuous coverage are (1) elevation angle for earth-moving cells and (2) satellite footprint reference location and coverage radius for earth-fixed cells. Thus, bearing in mind that this is the last RAN2 meeting in Rel-7, the rapporteur would like to ask the following question:

**Question 5: Do the companies agree that the two parameters mentioned below are sufficient to further improve support for discontinuous overage:**

1. **Elevation Angle for earth-moving cells**
2. **Satellite footprint reference location (coordinates) and coverage radius for earth-fixed cells**

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| --- | --- | --- |
| Company | Agree / Disagree | Comments |
| GateHouse | Agree |  |
| Nokia | * Either the evaluation angle or satellite coverage radius is OK for earth-moving cell. * Agree for earth-fixed cell (i.e., additional parameters: reference point and cell coverage radius) | We think both elevation angle and satellite coverage radius refer to same boundary circle on Earth. If coverage radius is used, we would assume the reference points for moving cell are at Nadir, so it can be deduced from ephemeris.  For earth-fixed cell, to enable coverage prediction, we assume the timing information when a serving cell is going to stop service and the timing when an incoming satellite will provide service are available in UE. |
| Novamint | Agree |  |
| Airbus | Agree |  |
| OPPO | Agree with comment | For earth-fixed cell, the satellite coverage radius and the satellite footprint reference point on ground are sufficient.  **Note that in the case of earth-fixed cell, the ephemeris orbital parameters and epoch time seem to be unnecessary.** Therefore, they are not mandatory present in SIB32 for earth-fixed cell.  The feasibility of elevation angle for earth-moving cell seems to be based on the assumption that the satellite always transmits the beam perpendicular to the earth ground. **We think RAN2 should first confirm this assumption before agreeing on the parameter of elevation angle.** Otherwise, RAN2 may still need to consider the **beam direction and cell radius information**. |
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**Rapporteur Summary**

<To be updated later>

## 3.6 Indication of Supporting Discontinuous Coverage

In R2-2202559 [7], it is mentioned that if the network using SIB if network can indicate that it supports the discontinuous coverage via SIB, then the UE can deactivate the AS layer function (e.g., monitoring, and periodic searching of cells) when the UE is in predicted discontinuous coverage. The discontinuous coverage starts when the UE loses coverage from the current satellite and can estimate the time for the next satellite. Although, the availability of mean satellite ephemeris for neighbour satellites in the new SIB could be enough for indicating the support for discontinuous coverage, R2-2202559 [7] suggests explicitly indicating the support for discontinuous coverage per PLMN via SIB1. Hence, the rapporteur would like to raise the following question:

**Question 6: Do the companies think that the network needs to explicitly indicate whether it supports discontinuous coverage per PLMN via SIB1?**

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| --- | --- | --- |
| Company | Yes / No | Comments |
| GateHouse | No direct preference for this | The need to have such explicit indication should be further clarified. It seems that the support for discontinuous coverage could be implicitly inferred by the UE just from the presence (or not) of the SIBs with the satellite assistance information for discontinuous coverage. |
| Nokia | No | Agree the availability of mean satellite ephemeris for neighbour satellites in the new SIB could be enough for indicating the support for discontinuous coverage. |
| Novamint | No | The availability of mean satellite ephemeris for neighbour satellites in the new SIB should be enough to explicitly indicate it supports discontinuous coverage |
| Airbus | No |  |
| OPPO | No | As stated by rapporteur, the availability of satellite assistance information for prediction of discontinuous coverage in SIB32 could be enough for indicating the support for discontinuous coverage. We don’t see the need on the enhancement by explicit indicator. |
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**Rapporteur Summary**

<To be updated later>

## 3.7 RRC Signalling and Handling of New SIB

During RAN2 117-e meeting it was agreed that RAN2 will use a new SIB to share the ephemeris information for Discontinuous Coverage with the UEs. However, the details of the parameters for prediction of discontinuous coverage and handling of the new SIB needs to be specified. Based on the RAN2 agreements and discussion until now, the rapporteur has identified the following parameters:

**New SIB**

1. Number of Satellites (*n*)
2. Satellite Id-1
   * Ephemeris Information (Orbital Parameters)
     + Ephemeris Type
     + Contents (as mentioned in Table 3)
   * Any additional parameter(s) agreed from Question 5 in Section 3.5
     + Type
     + Contents
3. Satellite Id-2

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Based on this information the rapporteur would like to raise the following question:

**Question 7: Companies are requested to provide their views on new SIB design and its contents (parameters) for prediction of discontinuous coverage.**

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| --- | --- |
| Company | Comments |
| GateHouse | We support the overall format of the SIB.  This approach gives flexibility to a network operator to select among different types of ephemeris types (e.g., Type 1 or Type 4) and among any additional parameter used to provide an indication of the size of the satellite coverage footprint (e.g., elevation angle for Earth-moving cells or reference location/radius for Earth-fixed cells). |
| Nokia | If only 1 ephemeris type is supported, there is no need to have “Ephemeris Type” in the SIB. |
| Novamint | We agree with Gatehouse as we believe it is important to give flexibility to the operators and we support the format and parameters proposed for the SIB |
| Airbus | We also agree with the new SIB design and contents as we also think some flexibility is beneficial |
| OPPO | Depending the format of epoch time, following information might be needed.  For example, if explicit epoch time is based on existing SIB 31’s format, i.e. SFN+subframe number, then validity duration seems to be needed so that UE knows when to autonomously reacquire the SIB 32. However, if explicit epoch time e.g. “32-bit EPOCH (4 byte)” or UTC time is adopted, validity duration might not be needed as NW can trigger SI modification procedure for UE to get the SIB 32 update. |
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**Rapporteur Summary**

<To be updated later>

# 4 Conclusion

<To be updated later with proposals>

# 5 References

1. RP-220943, Exception Request: IoT NTN (RAN2)
2. R2-115e Chair Notes EOM
3. R2-116e Chair Notes EOM
4. R2-116bise Chair Notes Jan 28 EOM\_rev2
5. R2-117e Chair Notes EOM
6. R2-2203860: [AT117-e][015][IoT-NTN] Miscellaneous Issues (MediaTek).
7. R2-2202559: Additional issues on the support of the discontinuous coverage (Qualcomm)