**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 |  |
| ZTE | Similar view as Nokia  Type 4 is also acceptable to us. | We also prefer a type with small size as SIB is sensitive to the bit overhead. Even for future releases, we don't think it's a good idea to provide neighbour satellite information via dedicated signalling.  But if satellite operators have strong views, Type 4 is also acceptable to us.  Moreover, we are a bit confused by the saying that***besides*** *the instantaneous orbital elements (Type 1), at least one of the mean element types would be selected*. Does it mean it’s still possible for network to provide one of two types orbital elements? If this is the case, anyway an indicator for indicating which type it is would be additionally needed in SIB. We don't want to see that more and more complexity is introduced for this feature.  Based on the agreement in last meeting, we understand only one type for mean orbital element would be provided, e.g., there would be no way to provide instantaneous orbital element in SIB32. |
| Ericsson | Type 3 | Although Type 2a or 2b are also acceptable. A validity of a few days would be enough in most discontinuous coverage scenarios (R1-2106776) where the maximum out of coverage interval would be ~14 hours. Even though SPG4 is widely used and provides the best accuracy (R2-2201017), this format is more complex and computationally expensive ([here](https://apps.dtic.mil/sti/pdfs/ADA531055.pdf) is a comparison). Given the stringent battery and low complexity requirements of IoT devices, we believe a simpler solution should be adopted. |
| CATT | Similar view with Nokia | Type 4 is also acceptable to us, if satellite operators have strong views on Type 4. |
| Thales | Type 4 prefered | SGP4 (TLE) as it is widely used. |
| ESA | Type 4 | Widely used by satellite operators. We acknowledge the comment from Ericsson, however it is difficult to quantify the added complexity, being most of the time implementation dependent. In addition, it shall be remembered that the validity is much longer, over which the potential increased complexity must be average out. |
| Eutelsat | Type 4 | Type 4 (SGP4) is the preferred option as the most widely used and permitting the highest accuracy at a few weeks horizon.  In addition, it should be noted that:  1) Parameters (9) "*mean motion 1st derivative"* and (10) "*Second time derivative of the mean motion*" were intended to SGP propagators and should not be needed by a SGP4 propagator (see [*SGP4 Orbit Determination*, from Vallado & Crawford]: "*We do not include estimates for mean motion rate and acceleration as they are not needed by the SGP4 routine. These values were included in the original SGP4 program to support users still using the SGP program. The terms essentially modeled the drag effect on the satellite. The BStar term accomplishes this in SGP4*" - see also [<https://celestrak.com/columns/v04n03/>])  2) Parameter (1) of Keplerian parameter "*Semi-major axis*" is replaced by SGP4 Parameter (6) (see [*SGP4 Orbit Determination*, from Vallado & Crawford]: "*Keplerian orbital elements (a, e, i, Ω, ω, M) can be used, but there can be singularities with some types of orbits. Notice the use of the semimajor axis instead of the mean motion.*")  These reduces the required size of 24 bits (*2nd derivative of the mean motion*) + 33 bits (*semi-major axis*), i.e. ~ 7 bytes from the estimated 33 bytes.  Size estimate for further reference:  **- Orbital parameters** w/o Semi-major axis: (1) Inclination, (2) RAAN, (3) eccentricity, (4) argument of perigee, (5) mean anomaly: 108 bits  **- (8) Epoch time:** 32 bits  - **Other SGP4 param**: (6) mean motion: 33 bits [Estimate], (7) revolution number at epoch 4 bit, (11) BSTAR drag term: 24 bits: 61 bits  So in total 201 bits / 26 bytes |
| Inmarsat | Partially agree | We share Ericsson’s view. What’s the point of deferring to Rel-18 if some work will have to be done anyways even if left to implementation? Either we think something needs to be standardized (at least for PSM) or it doesn’t. If something is needed, it has to be done now, no point postponing to Rel-18. If it’s not needed, and it’s deemed to be left to implementation, also no point in doing anything in Rel-18 |
| Ligado | Type 4 preferred | SGP4 (TLE) as it is widely used. |
| Sateliot | Type 4 | Type 4 (TLE) is actually a widely used approach in the satellite industry to predict the position of the satellite with good accuracy. In contrast, we are not aware of any use in practical systems involving Type 2a/2b/3.  With respect to the size in bytes needed to encode a TLE in the SIB (e.g. in the order of 33 bytes as per Table 3, or even less, according to Eutelsat’s considerations above), consideration should also be given to the fact that a TLE is to be broadcasted/updated less frequently because of its long validity (e.g. 3-4 weeks), therefore likely reducing in the end the network overhead.  With respect to complexity, SGP4 is a semi-analytical, not iterative algorithm, which is quite resource efficient and affordable to run in typical microcontrollers found in IoT modules.  For above reasons, we think that adding support in the standard for both Type 1 and Type 4 and allow a particular network deployment/operator to be using one or the other would actually cover most of the needs and trade-offs.  This approach is well in line with the SIB design proposal stated in Section 3.7, where the parameter “ephemeris type” can be used to indicate which type of contents (Type 1 or Type 4) is being provided for a particular satellite. |
| InterDigital | Type 4 | We should listen to the satellite operators preference. |
| Hughes/EchoStar | Type 4 | Widely used by satellite operators. |
| MediaTek | No Strong View |  |
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**Rapporteur Summary**

11 out of 17 companies, including almost all satellite operators have selected Type 4 SGP4 mean elements (extracted from e.g., NORAD TLE), as Type 4 provides the best accuracy ad are already in use in the satellites. 4 companies (Nokia, ZTE, Ericsson, CATT) suggested Type 2/Type 3, as these types are smaller (22 bytes vs 33 bytes) in size and less complex. ZTE has also mentioned that they are okay with Type 4 as well. Eutelsat has further mentioned that the size of Type 4 could be reduced to 26 bytes, making it comparable in size with Type 2/Type 3 (22 bytes). Sateliot has further indicated that type 4 Ephemeris is to be broadcasted/updated less frequently because of its long validity (e.g., 3 ~ 4 weeks), therefore likely reducing in the end the network overhead. Moreover, SGP4 is a semi-analytical, which is quite resource efficient and affordable to run in typical microcontrollers found in IoT modules.

Hence, based on the above discussion the rapporteur would like to propose the following proposal:

**Proposal 1: RAN2 will use SGP4 mean elements (Type 4) for sharing the mean ephemeris for discontinuous coverage.**

## 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?**

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| --- | --- | --- |
| 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. |
| ZTE | Yes | Epoch Time can be introduced if it is really needed by the selected mean element type in Q1.  Our further question is that, we understand epoch time may have relationship with the Typical Validity of the selected mean element type. If the Typical Validity can be several hours and even several weeks, do we need some way to indicate kind of very long epoch time for such mean element type? Please note currently there are only SFN and subframe information in epoch time for serving satellite in SIB31, then the straightforward question is, whether H-SFN would be also needed for the epoch time here? |
| Huawei, HiSilicon | yes | Do we also need a ‘validity duration’ or is it implicit from the ephemeris type? |
| Ericsson | Yes | We do not think that an implicit method can be used as the implicit method for uplink sync validity is based on SI window and for discontinuous coverage it is likely to be a number of ephemeris elements received from other satellites and it is unlikely that they will have an epoch time that coincides with SI window nor having the same epoch time. |
| CATT | Yes |  |
| Google | yes | Same question as ZTE, do we need to change the epoch time format to support such a long validity information? |
| Thales | Yes | Yes as the epoch time is a parameters of the ephemeris (Type 2a/Type 2b/Type 3/Type 4) |
| ESA | Yes |  |
| Eutelsat | Yes | Epoch time has to be explicitly indicated. |
| Inmarsat | Yes |  |
| Ligado | Yes |  |
| Sateliot | Yes | As pointed by GateHouse, “epoch time” is indeed one of the parameters that form part of the contents of ephemeris Type 4 (TLE) and as such have to be signalled along with the rest of the orbital parameters.  Also, agree with Ericsson’s observation that the epoch times of the ephemeris information sent for different satellites is unlikely to coincide (e.g., considering Type 4/TLE, the TLE of each advertised satellite will come with its own epoch time, which only indicates the time at which the TLE was determined). |
| InterDigital | Yes |  |
| Hughes/EchoStar | Indeed yes |  |
| MediaTek | Yes |  |
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**Rapporteur Summary**

All the 20 companies have agreed that RAN2 should explicitly use the epoch for sharing the mean ephemeris elements of serving as well as neighbour satellites, as “epoch time” is an integral parameter that of ephemeris Type 4 (TLE) and should be explicitly mentioned as mean elements will be updated less frequently. ZTE and Google has further mentioned if the format of epoch time needs to be changed from current format (SFN and subframe information, defined for the serving satellite) to support longer validity. Hence, based on this discussion the rapporteur suggests the following proposal:

**Proposal 2: RAN2 will explicitly use the epoch for sharing the mean ephemeris elements (of serving satellite, as well as the neighbour satellites) in IoT-NTN. RAN2 will discuss the possible format of epoch time as part of new SIB.**

## 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?**

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| --- | --- | --- |
| 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 |  |
| ZTE | Agree, that means we don’t discuss this in R17 | We don't think it's suitable to provide neighbour satellite information via dedicated signalling, for any release (to provide common information to multiple UEs is signalling inefficient).  We may need to consider some other simple type information via dedicated signalling, if really needed. |
| Huawei, HiSilicon | Agree |  |
| Ericsson | Disagree | We understand the strive to finish, but we think that the same content provided in SIB32 could be provided dedicated and this would not be too difficult to achieve. |
| CATT | Agree not to discuss in Rel-17 |  |
| Google | Agree |  |
| Thales | Agree |  |
| ESA | Agree | Not essential for this release. |
| Eutelsat | Agree |  |
| Inmarsat | Agree | The benefits are not very clear – it can be looked at in future releases if it reduces signalling overhead. |
| Ligado | Agree |  |
| Sateliot | Agree |  |
| InterDigital | Agree | Since R17 is mostly up to UE implementation anyway it is not clear what we are trying to achieve, so better to defer to R18. |
| Hughes/EchoStar | agreee |  |
| MediaTek | Agree |  |
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**Rapporteur Summary**

19 out of 20 companies have agreed to defer the use of dedicated RRC signalling to share neighbour satellites’ ephemeris information (required for discontinuous coverage), to the next release, i.e., Rel-18. Only ne company (Ericsson) has mentioned that same contents provided in SIB could be provided dedicated and will not be too difficult to achieve. Hence, based on the big majority, the rapporteur would like to propose the following proposal:

**Proposal 3: RAN2 will not discuss the use of dedicated RRC signalling to share neighbour satellites’ ephemeris information, required for discontinuous coverage of IoT-NTN, in Rel-17.**

## 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 |  |
| ZTE | Disagree | NAS layer has its standardized procedure to trigger some NAS processes, e.g. TAU request. Without any information of lack of coverage, we are not sure whether NAS layer can defer the NAS operation, e.g., purely by UE implementation, if trigger from higher layer is received?  Per our understanding, AS layer can at least deliver “the start-time of (incoming) satellite’s coverage and end-time of serving satellite’s coverage” that are received from SIBs to NAS layer and ensure consistent AS/NAS processes during lake of coverage. |
| Huawei, HiSilicon | Agree |  |
| Ericsson | Agree with AS-NAS interaction likely not being needed (if it is determined to be needed it needs to be done in Rel-17) | Technically there needs to be AS-NAS interaction, but we do not think it needs to be standardized as most AS-NAS interaction is not really standardized.  For PSM there is AS-NAS interaction, due to the PSM-logic is standardized and residing in NAS. However, for discontinuous coverage, the information is received over AS and then it is up to UE implementation where the logic of deciding out-of-coverage and in-coverage is done, which means that it can potentially also control NAS as well.  CT1 has been discussing some text for discontinuous coverage but it has been postponed, but as we understand it, there hasn’t really been a need for an interaction there.  Our proposal is to go on without any interaction and let RAN2 and CT1 introduce whatever is needed and if there is a “indicate to NAS …” needed then we can easily add this. No need to wait to rel-18 for this. |
| CATT | Agree with comments | We agree not to discuss this issue in Rel-17, but the current description seems like defining the WID scope of Rel-18. |
| Google | Agree |  |
| Thales | Agree |  |
| Eutelsat | Agree |  |
| Inmarsat | Partially agree | We share Ericsson’s view. What’s the point of deferring to Rel-18 if some work will have to be done anyways even if left to implementation? Either we think something needs to be standardized (at least for PSM) or it doesn’t. If something is needed, it has to be done now, no point postponing to Rel-18. If it’s not needed, and it’s deemed to be left to implementation, also no point in doing anything in Rel-18 |
| Ligado | Agree |  |
| Sateliot | Agree |  |
| InterDigital | Agree |  |
| Hughes/EchoStar | Agree |  |
| MediaTek | Agree |  |
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**Rapporteur Summary**

18 out of 19 companies have agreed that there is no need to agree on the standardization of any further details of AS-NAS interaction during discontinuous coverage. Only ne company (ZTE) has mentioned concerns as they are not sure whether UE implementation is enough to defer any NAS layer operation. Hence, based on the majority, the rapporteur would like to suggest the following proposal:

**Proposal 4: RAN2 will not discuss any further details of AS-NAS interaction for Discontinuous Coverage in IoT-NTN.**

## 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**

|  |  |  |
| --- | --- | --- |
| 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**. |
| ZTE | Agree on 2 (hope to introduce as few parameters as possible) | We think Satellite footprint reference location (coordinates) and coverage radius would be enough. As mentioned by Nokia, satellite coverage radius is also ok for earth-moving cell. |
| Huawei, HiSilicon | Agree on 2 only |  |
| Ericsson | Agree with 1. and 2. | We can introduce the parameters as suggested and make them optional. |
| CATT | Agree |  |
| Google | Agree on 2 | We share the same view as OPPO. |
| Thales | Agree | Agree with Ericsson, parameters can be optional |
| Eutelsat | Agree |  |
| Inmarsat | Agree with comment | Coverage radius is also valid for earth moving cells.  What about cell serving start/stop time for earth-fixed cells? I think it was agreed by many that it is required. Either explicitly or implicitly this parameter is needed for earth-fixed NGSO and dynamic GSO. |
| Ligado | Agree |  |
| Sateliot | Agree | We support the introduction of both types of parameters and make them optional. We think this is well in line with the SIB design proposal stated in Section 3.7, where the “type” value could be used for that purpose.  With respect to the elevation angle for earth moving cells, in order to consider the more general case where the coverage of the satellite should not be necessarily symmetrical around Nadir, this could be addressed by providing two values: a minimum elevation angle applicable to the rightmost point of the satellite cross-track line and another applicable to the leftmost point (see figure). |
| InterDigital | Disagree | We are fine to have these parameters, but don’t agree with the question itself – i.e. it is not clear what “sufficient to further improve support” means? It is hard to say whether it is sufficient or what it improves, since it’s up to UE implementation what to do with it – we have nothing to measure against and no testable requirements. |
| Hughes/EchoStar | Agree |  |
| MediaTek | No strong opinion |  |
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**Rapporteur Summary**

13 out of 18 companies agree to introduce both the parameters, i.e., elevation angle for earth-moving cells and Satellite footprint reference location (coordinates) and coverage radius for earth-fixed cells. Of the 13 companies, one company (Oppo) has further mentioned that before agreeing on elevation angle the assumption that satellite always transmits the beam perpendicular to the earth ground needs to be confirmed. 3 companies (Huawei, ZTE and Google) supported only Satellite footprint reference location (coordinates) and coverage radius for earth-fixed cells and not the elevation angle for earth-moving cells. One company (Interdigital) has disagreed on the ground that it is not clear what “sufficient to further improve support” means; although they are okay to have these parameters.

Hence, based on this discussion, the rapporteur would like to suggest the following proposal:

**Proposal 5: RAN2 will include support for Satellite footprint reference location (coordinates) and coverage radius for earth-fixed cells (besides already agreed coverage start and end-times). RAN2 will discuss if elevation angle needs to be included for earth-moving beams.**

## 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?**

|  |  |  |
| --- | --- | --- |
| 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. |
| ZTE | No | Scheduling of SIB32 can imply that network support discontinuous coverage. We haven’t seen the clear need of capability per PLMN. |
| Huawei, HiSilicon | No | First, R2-2202559 proposes having an indication per PLMN without any justification or description of how or why it is used.  Then, any per PLMN indication should come from SA2, not RAN2.  Finally, in accordance with TS 23.401 section 4.3.5.2, discontinuous coverage is essentially a RAN functionality, e.g. :  -. For UE using a RAN that provides discontinuous coverage (e.g. for satellite access with discontinuous coverage), if the UE knows how the E-UTRAN coverage varies with time based on information defined in TS 36.331 [37] (e.g. from the ephemeris data of a satellite access system that the UE is using) then the UE may deactivate its Access Stratum functions in order to optimise power consumption until coverage returns. Details are specified in TS 36.304 [34] and TS 24.301 [46].  …  Tracking Area or RAT specific MME configuration can be used to support UEs using a RAN that provides discontinuous coverage (e.g. for satellite access with discontinuous coverage).  We think that a PLMN that does not support discontinuous coverage, should not use /share a RAN that provides discontinuous coverage. |
| Ericsson | No | We also think that the scheduling of SIB32 can indicate the support of discontinuous coverage. We also tend to think that for a first release, a UE will not end up in a discontinuous coverage network by accident. In other words, since discontinuous coverage requires some rather unusual UE-abilities (being able to estimate when there is coverage), an operator would have to ensure that a UE that does not support discontinuous coverage does not attempt to connect to a discontinuous coverage satellite network by not configuring the UE with the PLMNs. This would not be done through indicating support via PLMN likely. |
| CATT | No |  |
| Google | No |  |
| Thales | No | Agree. The availability of the SIB can indicate if discontinuous coverage is supported. |
| ESA | No | The SIB is already an indication. |
| Eutelsat | No | Detection of mean ephemeris (assistance information) broadcast for the purpose of coverage discontinuities prediction is sufficient. |
| Inmarsat | No |  |
| Ligado | No |  |
| Sateliot | No, with comment | As indicated by other companies, it may seem that scheduling of SIB32 may already serve for that purpose. So, the need to have such explicit indication should be further clarified. |
| InterDigital | No |  |
| Hughes/EchoStar | No |  |
| MediaTek | No |  |
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**Rapporteur Summary**

All the 19 companies agreed that there is no need for the network to explicitly indicate whether it supports discontinuous coverage per PLMN via SIB1. Most companies also think that scheduling of SIB32 already serves for this purpose. Hence, the rapporteur would like to suggest the following proposal:

**Proposal 6: Network is not needed to explicitly indicate support of Discontinuous Coverage per PLMN by SIB1.**

## 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

….

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. |
| ZTE | We have similar view as Nokia that “Ephemeris Type” is not needed. See our comments for Q1.  Satellite list is already introduced in current SIB32. Could the index of each item be the Satellite Id? For this aspect, we think the current SIB32 may be flexible enough.  We are also considering that it may be possible to have a different epoch time format for mean element type (if needed), which is different from epoch time format for instantaneous serving satellite. |
| Huawei, HiSilicon | We also need to discuss whether updates to the SIB or part of the SIB are subject to SI modification notification procedure. We think this depends essentially on the signalling of epoch time/validity duration |
| Ericsson | Agree with others that ephemeris type should not be needed and that epoch time needs to be mandatory present. Any additional parameters outside of ephemeris and satellite ID can be optional.  Not sure why “number of satellites” need to be signaled. This should be obvious from the list size. Or is this the number of satellites in the constellation?  Satellite ID cannot be inferred by the position in the list.  Validity duration probably not needed. |
| CATT | Have the same view with ZTE on the “Ephemeris Type” and Satellite Id, and we also think the current 32 is flexible enough, but need more parameters. |
| Google | Ephemeris Information (Orbital Parameters) can be optional for the satellite providing quasi-Earth-fixed cell, especially if other information such as the reference location/radius are provided. |
| Thales | We agree with the overall SIB format |
| Eutelsat | The proposed structure is a good baseline |
| Inmarsat | Ephemeris type is implicit and for earth-fixed cells it should be either optional or re-purposed to convey other information about cell geometry and/or serving time.  But the general structure is a good baseline. |
| Ligado | Agree with the overall format. |
| Sateliot | Agree with the proposed format.  It would allow for flexibility in both, selecting the ephemeris type (e.g. Type 1 or Type 4), and selecting any other additional parameter used to give an indication of the size of the coverage footprint (e.g. elevation angle or centre location/radius) |
| InterDigital | Number of satellites isn’t needed, this is implied by the list size. It would be better to see a proposal for the ASN.1 definition itself. |
| Hughes/EchoStar | OK with proposed format |
| MediaTek | If only one ephemeris type is agreed, then there is no need to include type, otherwise (for supporting both Instantaneous and SGP4) the type needs to be included. |
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**Rapporteur Summary**

While many satellite companies have supported the proposed format, the details of the format need to be discussed.

* Some companies (Nokia, Ericsson, ZTE) have mentioned that if only one type (SGP4 or Type 4) is included, there is no need to mention ephemeris type.
* Similarly, number of satellites can be inferred from the list size defined and not needed
* Huawei has mentioned whether updates of SIB or part of the SIB are subject to SI modification notification procedure.

Based on this discussion, the rapporteur feels that detailed format of the SIB and its contents need to be discussed and finalized.

**Proposal 7: RAN2 will discuss and finalize the contents and format of the new SIB.**

# 4 Conclusion

**Proposal 1: RAN2 will use SGP4 mean elements (Type 4) for sharing mean ephemeris, to support discontinuous coverage in IoT-NTN.**

**Proposal 2: RAN2 will explicitly use the epoch for sharing the mean ephemeris elements (of serving satellite, as well as the neighbour satellites) in IoT-NTN. RAN2 will discuss the possible format of epoch time as part of the new SIB.**

**Proposal 3: RAN2 will not discuss use of dedicated RRC signalling to share neighbour satellites’ ephemeris information, required for discontinuous coverage of IoT-NTN, in Rel-17.**

**Proposal 4: RAN2 will not discuss any further details of AS-NAS interaction for Discontinuous Coverage in IoT-NTN.**

**Proposal 5: RAN2 will include Satellite footprint reference location (coordinates) and coverage radius for earth-fixed cells (besides already agreed coverage start and end-times). RAN2 will discuss if elevation angle needs to be included for earth-moving beams.**

**Proposal 6: Network is not needed to explicitly indicate support of Discontinuous Coverage per PLMN by SIB1.**

**Proposal 7: RAN2 will discuss and finalize the contents and format of the new SIB.**

# 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)