**3GPP TSG RAN WG2 #118-e R2-220xxxx**

**Online, 9th – 20th May, 2022**

**Agenda Item: 7.2.4**

**Source: GateHouse**

**Title: [draft] Report of [AT118-e][057][IOT NTN] Discontinuous coverage (Gatehouse)**

**Document for: Discussion**

# Introduction

This document is the report from the following offline discussion:

* [AT118-e][057][IOT NTN] Discontinuous coverage (Gatehouse)

      Scope:

 1. Based on Agreements related to R2-2205933, progress further to identify agreeable parts.

 2. Treat R2-2206160, determine agreeable parts (and related TPs)

      Intended outcome: Report, agreeable parameters definitions (TP)

      Deadline: For Online CB W2 Tue

During the 1st round of discussion, the rapporteur invites companies to provide their comments before the deadline that is set to: **Monday, 16th of May – 1200 UTC.**

Hereafter the rapporteur will summarize, and the summary will be made available for the online session on Tuesday, 17th of May.

# Contact

Delegates are encouraged to provide their contact information in the following table:

|  |  |  |
| --- | --- | --- |
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# Agreements

This document is intended for discussion and agreement of parameters related to the discontinuous coverage case. The discussion will be based on the [post-RAN2#117-e discussion](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2205933.zip) and the proposals of [R2-2206160](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2206160.zip).

The following agreements, based on the [post-RAN2#117-e discussion](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2205933.zip), were made during the [first NTN IoT online session](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Inbox/Chairs_Notes/R2_118-e%20Chair%20Notes%202022-05-10%200600%20UTC.docx) in RAN2#118-e:

* P2, P3, P4, P6 are agreed
* P1 is agreed (can explore during R2 118-e whether optimizations/removal of some info is possible, optionality etc).
* (based on P1) Go for a single format / type of mean parameters for prediction of coverage (overrides earlier agreement).
* Include Satellite footprint reference location (coordinates) and coverage radius (for earth-fixed cells).
* Discuss further during R2 118-e for earth moving beams, and also clarify details for earth fixed cells (if needed)

The post-RAN2#117-e proposals:

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.

Color code: Agreed, to be discussed.

# SGP4 ephemeris and Satellite footprint parameters.

As agreed, the satellite assistance information (SAI) to be transmitted in SIB32 consists of coverage information. This may come in the form of ON-timestamps for the earth-fixed (EF) scenario or as an SGP4-ephemeris in the earth-moving (EM) scenario, satellite footprint parameters and possibly a satellite/beam number.

## SGP4 ephemeris

### SGP4 reference frame

The standard reference frame of SGP4-propagators is true equator, mean equinox (TEME) of the epoch.

Question 4.1: Do you agree to specify the reference frame of the SGP4 format as TEME at epoch?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilicon | Yes | trust the satellite companies |
| Ericsson | Yes |  |
| MediaTek | Yes |  |
| ZTE | - | Can trust the satellite companies, but there are still ambiguities that would affect our understanding on the whole scheme and consideration on signalling details. Honestly to say, we feel it’s difficult to discuss these things in RAN, especially in RAN2 scope. In [[R2-2206160](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2206160.zip)], only one sentence mentions TEME as below:“*The reference frame of the SGP4/SDP4 orbital models are coordinates in the Earth-centred inertial (ECI) frame with regards to true equator, mean equinox (TEME) of epoch.*”Per our knowledge, we have the following clarifications:* The SGP4 model can only accurately propagate the orbit of objects near Earth (with an orbital period shorter than 225 minutes, corresponding approximately to an altitude lower than 5877.5 km). For propagation of objects in deep space (with an orbital period longer than 225 minutes), the SDP4 model should be used. Then here in 3GPP, do we only need to specify SGP4, not include SDP4, right? (the consideration may be that orbital period of LEO would not be longer than 225 minutes while GEO has no discontinuous coverage issue? Then how about MEO?)
* True equator, mean equinox (TEME) is a type of coordinate system. There are other types of coordinate system, e.g., Mean Equator Mean Equinox (MEME). In [[R2-2206160](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2206160.zip)], there are some discussion on how to simplify the elements included in TLEs and finally some elements are proposed in Proposal#4 in [[R2-2206160](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2206160.zip)]. But it’s not clear whether the selected elements are aligned with TEME coordinate system? Or if there is understanding that TLE and SGP4 can only be used in the TEME coordinate system, then TEME would be confirmed and it’s no need to discuss Q4.1.
 |
| Eutelsat | Yes |  |
| Lenovo | Yes |  |
| Nokia | Yes |  |
| CATT | Yes |  |
| Google | Yes |  |
| OPPO | Yes |  |
| Inmarsat | Yes | The question about MEO is legitimate, as in our understanding we assume that upon signalling of different orbits such as MEO or GEO a different propagator would have to be used by the UE (subject to UE implementation). Since the TLE input for SGP4/SDP4 are, in our understanding, the same, there should be no need to specify anything further.To further clarify - GEO/GSO **may** have discontinuous coverage issue, but this is not given by changes in the satellite position of course, but rather by a time-varying cell illumination plan. |
| InterDigital | Yes |  |
| Sateliot | Yes |  |
| Novamint | Yes |  |
| GateHouse | Yes |  |
| Hughes/EchoStar | Yes |  |

### Summary - Question 4.1

Companies agree to the standard TEME at Epoch format for the SGP4 propagator.

In addition, for ZTE’s comments/concerns:

1. Inmarsat is correct that SGP4/SDP4 should work with the same parameter format.
Commonly SGP4 is used to refer to the set of both SGP4/SDP4, but we should rightly be specific that it is both SGP4 and SDP4.
2. TEME is a standard for the SGP4/SDP4 propagator. All SGP4/SDP4 mean parameter sets must be generated based on SGP4/SDP4 operations on TEME data. The output of the SGP4/SDP4 propagators are also in TEME.

Basically, this means TLEs published by Space-track and Celestrack can be used, and standard propagators, such as the one provided by space-track.org (after signup under Help->SGP4->ZIP) can be used.

### SGP4 parameters

In[R2-2206160](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2206160.zip) it is proposed that the range and granularity of the orbital parameters needed for SGP4 propagation should be based on the ranges and granularity already defined for TLE since the TLE is a well-known and tried standard-format for SGP4 parameters in the satellite community.

However, the elements included in TLEs [2] go beyond the requirements for SGP4 so that some of them could be skipped. In particular, the derivatives of mean motion, both first and second order, are not needed for SGP4 propagation [7], but are part of the TLE for compatibility reasons. In addition, the international designation of the satellite is not necessary for orbit propagation.

The necessary SGP4-based ephemeris parameters are further detailed in Table 2. The parameters in Table 2 are specified based on a conversion of the range/state-space covered by the character-encoded parameters in the TLE format (see Figure 2 and [9]) to state encoded parameters in Table 2.

 **Table 2**. SGP4 parameters: Units, range, bit size and granularity.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameter | Unit | Range | Min states | Nearest Bit | States | Granularity |
| *Example* | *SI* | *X to Y* | *Smin* | *B =* ⌈log2*(Smin)*⌉ | *S = 2B* | *(Y-X)/(S-1)* |
| Inclination | Deg | 0 to 180.0000 | 1800001 | 21 | 221 | 8.583073616e-5 |
| Arg of Perigee | Deg | 0 to 180.0000 | 1800001 | 21 | 221 | 8.583073616e-5 |
| Right Ascension of the Node | Deg | 0 to 360.0000 | 3600001 | 22 | 222 | 8.5830712318e-5 |
| Mean Anomaly | Deg | 0 to 360.0000 | 3600001 | 22 | 222 | 8.5830712318e-5 |
| Eccentricity | - | 0 to .9999999 | 1e+7 | 24 | 224 | 5.96046388e-8 |
| Mean Motion  | rev/day | 0 to 99.99999999 | 1e+10 | 34 | 234 | 5.82076609e-9 |
| ~~Revolution Number at Epoch~~  | ~~rev~~ | ~~0 to 131071~~ | ~~131072~~ | ~~17~~ | ~~2~~~~17~~ | ~~1~~ |
| B\* |  (earth radii)-1 | Nonlinear∓.99999∓9 | - | 23 | - | - |
| Epoch\* | sec | -1048575 to 1048575 | 221 - 1 | 21 | 221 | 1 |

Notes:

1. B\* is defined in TLE format as the string “∓CCCCC∓E” - where ∓ is a binary sign, C is a value 0 through 9 and E is an exponent valued 0 through 9. The nearest bit is very close to the required number of bits (21.93) hence we keep the industry standard intact and do not attempt to improve the nonlinear granularity. A decimal point is assumed after the initial sign. To clarify the bitmask for the B\* term we provide the following:
	1. Bit 0: Determines the sign of the decimal.
	2. Bit 1-17: Determine the value of the decimal, range: .00000 to .99999, nBits = 17, granularity: .00001.
	3. Bit 18: Determines the sign of the exponent.
	4. Bit 19-22: Determine the value of the exponent, range: 0 to 9, B = 4, granularity: 1.
	5. For bit 1-17 and bit-19-22 they can represent more cases than required by the granularity. However, the extra cases shall be disregarded, i.e.. the integers beyond the range of 99999 and 9, respectively, are discarded.
2. The granularity of the number of revolutions should be the integer 1 so the range has been extended from the TLE formats maximum of 99999 to 131071.
3. The variables, ”*Inclination, Arg of Perigee, Right Ascension of the Node, Mean Anomaly, Eccentricity and Mean Motion*“ all have slightly improved granularities compared to TLEs due to “extra” states being introduced when per-parameter encoding is introduced in contrast to TLEs character encoding.

This is a total of 205 bits, or 25.625 Bytes.

Question 4.2: Do you agree to specify the range and granularity of the orbital parameters needed for SGP4 propagation ..

1. .. based on the ranges and granularity already defined for TLE parameters
2. .. and adopt the parameters specified in table 2 for the SGP4 format? Any suggestions in comments.

 Epoch to be discussed in the next question

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilicon | Yes | trust the satellite companies |
| Ericsson | Yes |  |
| MediaTek | Yes |  |
| ZTE | Yes to specify the range and granularity | We understand satellite companies would prefer option b, right?Our further comments:It’s not clear why the value range of “the number of revolutions” is to be extended from 99999 to 131071. Is the intention here just to simply use up all the value range of 17bits? Is it really needed?Moreover, we understand the original counting of the number of revolutions is from the real epoch time, e.g., from the launch time of the satellite. Now, as satellite companies suggest a variable Epoch\* parameter, does the meaning and value range of the number of revolutions also need to be changed accordingly? |
| Eutelsat | Yes | Note: A further suggestion is - for avoiding confusion - to reflect the original TLE parameters names in the ASN.1 structure (in particular "Argument of perigee" - vs. "periapsis", and " Right ascension of node" vs. "longitude") |
| Lenovo | Yes |  |
| Nokia | Yes |   |
| CATT | Yes |  |
| Google | Yes |  |
| OPPO | Yes |  |
| Inmarsat | Yes with comments | We agree with Eutelsat’s suggestion.  |
| InterDigital | Yes |  |
| Sateliot | Yes | Agree with previous suggestion of reflecting the names of the original TLE parameters |
| Novamint  | Yes  | Support Eutelsat’s suggestion of reflecting the original TLE parameters names |
| GateHouse | Yes | Agree to EUTELSAT suggestion (supported by INMARSAT, SATELIOT) |
| Hughes/EchoStar | Yes |  |

The variable Epoch\* is a time offset between the beginning of the current week (Monday 00:00:00 UTC) of the SGP4 Epoch.

1. The Epoch time parameter within TLE is encoded as the last two digits of the Epoch year, and the Epoch day down to a granularity of ~1 microsecond and would need 44 bits. To reduce this size, Epoch\* defines the offset to the actual Epoch and is limited to a range of +/- 1048575 seconds (+/- ~12.1 days) referenced at the start of the current week. (This is considered a sufficient time to have a new TLE update).
2. It is reasonable that a new ephemeris is available before the old ephemeris (and any propagations) becomes too inaccurate. In the (unlikely) case that SGP4 ephemerides have Epochs that lay outside of this range, those can reasonably be propagated to the current week before being broadcast. Propagated ephemerides neither gain nor loose accuracy compared to the original ephemerides.
3. Since the SAI is for aiding UEs to predict coverage in the DC scenario a granularity of 1 sec is very reasonable as the added energy consumption for a UE to wake up approximately half a second in advance of predicted coverage (excluding prediction error over time) is negligible.

### Summary - Question 4.2

Companies agree to the proposed SGP4/SDP4 ASN.1 parameters.

Per Eutelsat’s suggestion the naming convention should follow that of the conventional TLE format.

In addition, for ZTE’s comments/concerns:

1. There is no need for this extension, as you note it is just to use up the value range and keep the granularity to 1.
2. The number of revolutions parameter is the number of revolutions that has passed from satellite launch to Epoch.

Anyway, this is an identifying parameter in the TLE-format and not used for the SGP4 propagator so upon your comment I have removed this parameter.

Question 4.3: Do you agree to specifying Epoch\* as a substitute for Epoch based on the above formulation?

* 1. Epoch\* as an offset to Epoch
	2. Epoch\* with reference to the beginning of the current week, Monday 00:00:00 UTC
	3. Epoch\* with granularity of 1 sec and a range of $\pm \frac{2^{21}-1}{2}$ seconds (~12.1 days) around the reference time.0
	4. It is up to the network to appropriately propagate the SGP4-parameters if they fall outside this range

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilicon | yes in principle | a) we welcome reducing the size of the parameterb) does that mean that the UE needs to know the (current) UTC time, i.e. that SIB16 shall also be broadcast |
| Ericsson | Yes |  |
| MediaTek | Yes |  |
| ZTE | Yes in principle | Epoch\* defines the offset between the actual Epoch and the beginning of the current week (Monday 00:00:00 UTC), right?We have same question as Huawei, does it mean UTC time in SIB16 also need to be broadcasted? We hope not but still not sure whether Epoch\* can be workable without time info from SIB16. |
| Eutelsat | Yes | It is assumed that ephemeris should be updated frequently enough (e.g. once per day or more) so that a UE would get a fresh enough ephemeris set at any wakeup moment, and would be able to compute a prediction with an optimum accuracy even after a (reasonably) long sleep time period. |
| Lenovo | Yes with comments | For the concerns in b), in our understanding there is no need of current UTC time in SIB16, as the Epoch\* is with reference to the beginning of the current week (Monday 00:00:00 UTC) which is already known. |
| Nokia | Yes |  |
| CATT | Yes |  |
| Google | Yes |  |
| OPPO | Yes | SIB16 is not necessary for Epoch\*. Anyway, an NTN UE shall support GNSS for pre-compensation, so it can obtain the UTC time precisely using GNSS, and Epoch\* without the time info in SIB16 would be workable. Therefore, we are fine for the 21-bits Epoch\*. |
| Inmarsat | Yes | In response to concerns by Huawei and ZTE, in our understanding, yes the UE will need to know the current UTC time implicitly anyways (and thus have to maintain an up to date internal clock) to be able to decide when to wake up, so there is no need to further communicate the UTC time in SIB16. It is assumed that the UE clock is correct and can determine current time (GNSS or other means).Epoch\* with reference to a previous, agreed-upon instant in time of the running week (i.e. Monday 00:00:00 UTC) is sufficient to be signalled so the UE can recover the ephemeris full Epoch.  |
| InterDigital | Yes |  |
| Sateliot | Yes, with comments | We agree with the formulation to reduce the size of the “Epoch” parameter. About the UTC time, we share Inmarsat’s observation that the UE should know UTC time in any of both cases (whether “Epoch” is encoded using 44 bits according to the original TLE format or “Epoch” is just encoded with 21 bits, as proposed here).We think that a UE can get the UTC time from its GNSS receiver. But not sure if UTC broadcasting with SIB16 should be mandated anyway to consider the case of UEs that may be at fixed locations (i.e. with pre-defined/pre-provisioned geographical coordinates) and not necessarily relying on an GNSS receiver (given the location is fixed and the UE can still solve the UL pre-compensation).  |
| Novamint  | Yes  |  |
| GateHouse | Yes | The UE is expected to be in-sync to UTC time when processing SGP4 Epoch. |
| Hughes/EchoStar | Yes |  |

### Summary - Question 4.3

Companies agreement that the “differential epoch” Epoch\* can be used.

It is the understanding of the repparteur that the Epoch needed by the SGP4 propagtor is “Ds50UT1” or days since 1950 in UTC1 (UT1). So a UTC reference is required. The question is whether the UE can optain the UTC reference from GNSS or it must obtain the reference from SIB16.

SIB16: Huawei/HiSilicon, ZTE,

GNSS: Lenovo? OPPO, Inmarsat, GateHouse, Satelliot

## Quasi earth fixed parameters

From [R2-2206160](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2206160.zip):

“The service start time, or “t-Service-r17” in [TS 36.311v17.0.0] is intended for quasi-earth-fixed cells. We have made the following observations:

1. TimeUTC-r17 is a 39 bits parameter than ranges over ~1700 years starting from Jan 1 1900 with a granularity of 10 ms. We believe this is excessive for scheduling MO-traffic opportunities between paging opportunities and the parameter range could be reduced to a range of one week with a granularity of one second to significantly reduce the ASN.1 parameter size.
2. We suggest transmitting a list of timestamps, instead of just one, that can be up to X long to match the bit size of the ephemeris parameters (X=10 for the proposed range/granularity). This will allow for several MO-traffic opportunities to be scheduled for UEs in quasi-earth-fixed cells between scheduled paging opportunities (MT-traffic).
3. The parameter name “t-Service-r17” causes some confusion with regards to the purpose of the parameter, e.g. it seems to indicate a service period, so we suggest renaming it in some way to include “Start” – for example “tServiceStart-r17”.
4. If the Quasi-Earth-fixed cell scenario is extended with additional parameters that are specific to the scenario in future Release, it would be advantageous to gather the related parameters, eg. tServiceStart-r17 in a SEQUENCE that can be extended in future releases.

**…**

ASN.1 coding example for 2, 3, 4 above:

|  |
| --- |
| -- ASN1STARTSatelliteInfo-r17 ::= SEQUENCE { satelliteSAI-r17 CHOICE { ephemerisOrbitalParameters-r17 EphemerisOrbitalParameters-r17 sgp4EphemerisParameters-r17 SGP4EphemerisParameters-r17  earthFixedCellParameters-r17 EarthFixedCellParameters-r17 nonCriticalExtension SEQUENCE {}  } satelliteID-r17 INTEGER (0..255) OPTIONAL, nonCriticalExtension SEQUENCE {} OPTIONAL, ...} EarthFixedCellParameters-r17 ::= SEQUENCE { t-ServiceStart-r17 SEQUENCE( SIZE (1..10)) OF INTEGER (0..1048575) nonCriticalExtension SEQUENCE {}}-- ASN1STOP |

“

**Question 4.4: Do you agree to specifying the above “EarthFixedParameters-r17” type - for the earth-fixed scenario?**

Rapporteur’s notes: This specification makes three changes:

1. It embeds “t-ServiceStart-r17” in a “EarthFixedParameters-r17” type along with a empty SEQUENCE “noncritical extensions”, which allows for extensibility to this type for earth-fixed cells in future releases.
2. It redefines “t-ServiceStart-r17” from the type “TimeUTC-r17” an “INTEGER (0..1048575)” This defines a time difference ranging from 0 to ~12.1 days from the beginning of the current week (Mon, 00:00:00 UTC with a granularity of 1 sec) to the time that coverage starts.
This proposed type is 20-bits instead of the 39-bit TimeUTC-r17.
3. It allows for the transmission of a list of several “t-ServiceStart-r17” instead of allowing only a single “t-ServiceStart-r17” to be informed. This allows for more opportunities to transmit mobile-originating traffic. To match the size of the proposed ASN.1 type for SGP4 ephemeris then up to 10 such timestamps can be allowed per “EarthFixedParameters-r17”.

Additional: This does NOT exclude footprint parameters or beamID from being included in SIB32. Specific questions on footprint parameters and satellite / beam ID follow.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilicon | Yes | same as for EpochTime in Q4.3, does that means that the current UTC time should be known, i.e. SIB16 be broadcastIf we agree on this, we think the same should apply to t-Service in SIB3 (i.e. time when the serving cell stops service) |
| Ericsson | No | No need for the optimization of signalling multiple t-Service. We think it is really too late for these type of optimizations and we think that the UE would have to wake up to read system information occasionally to receive paging etc, so we do not really see the need for multiple t-ServiceStart.  |
| MediaTek | es |  |
| ZTE | Yes in principle | We have the further comments as below:* Same comments as Huawei for SIB16 and for t-Service in SIB3.
* For earth-fixed scenario, we understand the intention of above #3 change is to provide at most 10 (seems too many?) service start times for each satellite. From signalling perspective, the scheme seems less optimized. We are wondering whether the format can be [the first service start time + [periodicity](https://dict.cn/periodicity)] or [the first service start time + a list of offset], here each offset means the time offset between the current entry of service start time and the first service start time.
 |
| Qualcomm | No | This signaling structure is presented so badly.There should be only critical extension inside CHOICE.There is no need of having non-critical extension and extension marker together.earthFixedCellParameters-r17 Can be outside CHOICE and can be Need OR which is present probably in the case of fixed cell.But we are ok with multiple service times. |
| Lenovo | Yes with comments | For t-ServiceStart-r17 we share Huawei’s concern as it may be based on current UTC time, which is different from the Epoch\*. |
| Nokia | Yes | OK to have multiple service times which may save UE’s power consumption for SIB reading. |
| CATT | No | Have the same view with Ericsson that, it is too late to define a new structure. For the coverage prediction of earth-fixed cell, one t-Service is enough for one cell, and the t-Service should be associated with a specific cell.  |
| Google | Comments | We are fine with the CHOICE structure and the renamed tServiceStart-r17, but not sure about the critical/non-critical extension part. We don’t think it is needed to have multiple tServiceStart-r17 for the same satellite. |
| Xiaomi | No | In our understanding, for the quasi earth fixed scenarios, network only need to provide timing information and footprint parameters for UE to predict the discontinuous coverage, there is no need to provide ephemeris data additionally. So there is no need to match the t-service with the size of the proposed ASN.1 type for SGP4 ephemeris and the multiple service times is also not needed. |
| OPPO | Yes for 2)No for 1), 3) | For change 1), this should be left to the 36331 rapporteur.For change 2), as stated in Q4.3, anyway, an NTN UE can obtain the UTC time precisely using GNSS, so we are fine for 20-bits t-ServiceStart-r17.For change 3), as same view as Ericsson, we don’t see the need of the optimization of signalling multiple t-ServiceStart-r17 as a sequence. |
| Inmarsat | Yes with comment | We are ok to have multiple service start times, but we also agree that t-Service should probably be associated with a specific cell index. In the baseline case, cell-index can correspond to whole satellite in cases where a satellite handles a single cell. |
| InterDigital | No | No strong view whether to specify a new IE to contain the earth-fixed parameters. It seems that there is only one additional parameter (i.e. t-ServiceStart-r17) so this could also just be added in the top level structure. We note that t-Service-r17 is missing from the above TP – both start and end times are needed, but we assume this is just an error in the TP, this parameter is in the current specification – it shouldn’t be removed or replaced.It is also not clear why there would be multiple start times – there should logically be one start and one end time per satellite to indicate the duration of coverage.Also agree with QC that the t-ServiceStart can be outside of the CHOICE structure and that only one nonCriticalExtension is needed. Additionally there are missing commas in the structure, but we can fix this once agreeing upon the principle of what the signal. |
| Novamint | Yes  | Agree with Inmarsat |
| GateHouse | Yes |  |
| Hughes/EchoStar | Yes  |  |

### Summary - Question 4.4

The same question as to whether the UE can optain the UTC reference from GNSS or it must obtain the reference from SIB16 is presented.

No consensus on defining multiple t-service times: 8 against, 7 for/neutral

Consensus of redefining T-serviceTimeStart-r17 to be a time difference instead of the timeUTC type.

Some objections to including a CHOICE structure many towards having an extendable SEQUENCE type for earth-fixed-parameters.

Rapporteur proposes to see if we can agree on the CHOICE structure and using differential time for t-ServiceStart-r17.

1. CHOICE structure since the earth-moving and earth-fixed scenarios DO NOT mix.
2. The agreed upon t-serviceStart-r17 optimization provided that the GNSS/SIB16 debate can be resolved.

Updated ASN.1 example:

|  |
| --- |
| -- ASN1STARTSatelliteInfo-r17 ::= SEQUENCE { satelliteSAI-r17 CHOICE { sgp4EphemerisParameters-r17 SGP4EphemerisParameters-r17  t-ServiceStart-r17 INTEGER (0..1048575) } nonCriticalExtension SEQUENCE {} OPTIONAL, ...}-- ASN1STOP |

## Satellite footprint parameters

RAN2#118-e agreement:

* 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.

This is in line with proposals made in [R2-2205598](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2205598.zip) and [R2-2206160](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2206160.zip). The following will discuss the schemes and parameterisation for satellite footprint parameters for the cases of earth-fixed (EF) cells and earth-moving (EM) cells.

### Reference point and radius (EF+EM)

In this scheme a reference point as a set of coordinates and a radius will define the edge of a beam (EF) or a cell (EM)

**Rapporteur’s proposal:**

Reference frame: WGS 84

Reference coordinates: Longitude and Latitude
 Range: 180.000 to 180.000

 Granularity: 0.00068664681 Deg (< 100 meter on Earth’s surface)
 Bits: 19 x2

Radius:

 Range 10 to 2560 km

 Granularity: 10 km.
 Bits: 8

So 46 bits in total, or 5.75 Bytes.

Question 4.5: Do you agree to the rapporteur’s proposal for refencepoint+radius signalling? And do you agree to allowing this footprint parameter to be sent in both the Earth-moving and Earth-fixed scenarios?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilicon | Yes |  |
| Intel | Yes | These footprint parameters are also beneficial for UE to predict Earth-moving coverages. |
| Ericsson | Comments | First of all, our understanding is what is being signalled is not beam coverage, but satellite coverage. This means that there will only be a single coverage parameter per satellite, and not multiple for each beam within a satellite. We are really confused by “*coordinates and a radius will define the edge of a beam (EF) or a cell (EM)*”. We understand that reference location and radius is what has been agreed for earth-fixed, but we cannot understand how this is used for Earth moving. We agree to this being used for earth-fixed.  |
| MediaTek | Yes |  |
| ZTE | Yes |  |
| Qualcomm | Yes but | Due to signaling overhead, beam edge radius may not be important to broadcast. Simply what it matters is coverage of a beam. The UE just needs to detect a beam, but it can select any cell found suitable. We do not see more optimization than this.For moving cell, the reference coordinates should correspond to the epoch time of the ephemeris so that the UE can project the reference coordinates at time t.  |
| Eutelsat | Yes with comment | - As long as they remain optional parameters- We have the same understanding as Ericsson that these parameters are for the overall satellite coverage as they are used for predicting UE wakeup time |
| Lenovo | Yes with comments | We share Ericsson’s view that it should be a single coverage parameter per satellite. Besides we prefer to use EM for moving cell, while if we use refencepoint+radius in moving cell, it may also necessary to indicate the velocity of the referencepoint as well. |
| Nokia | Yes with comments | We think reference point and radius is useful for both EMC and EFC scenarios. But for EMC it may be challenging to define the reference point as a location on Earth, because it keeps moving i.e., it may need to be complemented with a time stamp. Alternatively, the reference point can be given as a point/angle relative to the satellite’s position (e.g. under the nadir). If this is the case, then the reference point can be omitted which means NW only needs to provide the satellite radius.We share the view that only 1 set of parameters is given per SAI. However, we think it is NW implementation to decide it is satellite coverage radius or cell coverage radius. E.g., for EFC, it is cell radius to support the spot beam to cover an island. But for EMC, it is satellite coverage radius since one satellite may support multiple cells which can serve the UEs. |
| CATT | Comments | We agree that reference point and radius can be used for earth-fixed. But also not sure how this can be applied to earth-moving cell, maybe time information associated with the reference point is needed. |
| Google | Yes, but only for the earth-fixed scenario | We share the same view as Ericsson that the reference location and radius are only for the quasi-earth-fixed cell (i.e., they should only present inside the ‘earthFixedCellParameters-r17’ IE). |
| Xiaomi | Yes with comments | Agree with Ericsson that only a single coverage parameter is for one satellite. For earth moving cell, we are not clear how the reference location is implemented, and we have a concern it may lead the UE to predict the reference location based on some additional information. We agree it is used only for earth fixed cell. |
| OPPO | Yes for earth-fixed  | We agree to the rapporteur’s proposal for refencepoint+radius signalling, but we have the same understanding as Ericsson that whether the reference point and radius could be workable for earth moving cell is not clear.  |
| Inmarsat | Yes with comment | In any case (applies to both EMC and EFC), the reference point has to be either assumed or explicitly signalled to be at a given Epoch in line with Ephemeris so that the UE can determine it at any given instant “t”.In case of a multi-beam satellite, if the data indicates only full satellite coverage, the UE has to have a-priory knowledge of the coarse beam/cell pattern of the satellite, or at least make an assumption on the number of beams.Maybe a better/more flexible solution could be to leave it such that it can be used per-beam/per-cell, but as a baseline case, it indicates the full satellite coverage (e.g. index 0) and the choice on what to use can be left to NW implementation. This would cover both multi-beam systems with explicit or implicit beam signalling, as well as single-beam-per-satellite systems. |
| InterDigital | Yes |  |
| Sateliot | Yes, for earth-fixed.No, for earth-moving. | For earth-moving cells, the “reference point + radius” should necessarily be given as a relative point with regard to e.g. Nadir point of the satellite. However, for that purpose, we think that just providing two elevation angles (as covered in Q4.6) is enough and requires less bits |
| Novamint | Yes, but only for earth-fixed | For earth-moving, agree with Sateliot’s comments |
| GateHouse | Yes |  |
| Hughes/EchoStar | Yes |  |

### Summary - Question 4.5

Full agreement for the Earth-fixed cell scenario.

Can be discussed whether to also allow the radius (only) for the earth-moving case with nadir as reference.

Companies need to align on their understanding of beams, cells and what is the purpose of SAI especially for the Earth-fixed scenario.

To the rapporteurs understanding:

1. The purpose of the SAI is to ensure UEs can save energy, but will still have MO/MT- traffic capabilities (critically wake up for monitoring paging)
2. The SAI includes EITHER information for Earth-moving OR earth-fixed case.
3. A single beam can be a cell in the earth-fixed case – in fact this emulates a terrestrial network - so different SIB can clearly be sent for each beam.
4. SIB32 can be used to inform on SAI for a list of satellites in the Earth-moving case.
5. SIB32 can be used to inform on a single t-serviceStart-r17 time for a list of Earth-Fixed cells.

### Elevation angles (EM only)

In this scheme two elevation angles, define the cross-track (axis orthogonal to the direction of the satellite) footprint coverage width. In this scheme the elevation angles are given with regards to the satellite position. In [R2-2206160](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2206160.zip) the following description is made:

If a single value is given, the “Right-” and “Left minimum elevation angles” are assumed equivalent. That is, the footprint is even around the satellite track. To describe a footprint coverage that is offset from the satellite track, two minimum elevation angle thresholds can be specified. The right minimum elevation angle is the rightmost (with reference to the satellite direction) elevation angle. The left being the leftmost. Both angles can be given from -70 to 70 allowing a leftmost elevation angle to be placed on the right side of the reference satellite. A “left minimum elevation angle” that is located to the right of the reference satellite is indicated by a negative sign on the elevation angle and equivalently for a “right minimum elevation angle” to the left of the reference satellite. See Figure Y.



**Figure Y**. Satellites travelling “into the paper”. The left satellite depicts the case of a footprint cross-section that is even around the nadir and so a single elevation angle “a” is necessary to describe the case. In this case a UE will be within the footprint if the minimum elevation angle the UE will experience during a satellite pass is greater than “a”. The satellite to the right projects a footprint to the left of the satellite: the “right minimum elevation angle”, “b”, is on the left of the satellite - it is measured as any other elevation angle, but assigned a negative sign. In this case a UE will be within the footprint if the minimum elevation angle the UE will experience during a satellite pass is greater than “a”, less than “b” and the UE is located on the left of the satellite pass.

**Rapporteur’s proposal:**

Reference point: Associated SGP4 satellite

Elevation angles:

 Range -70 to 70 Deg

 Granularity: 10 Deg
 Bits: 4 x2

So 8 bits in total.

**Question 4.6:** Do you agree to the rapporteur’s proposal for elevation angle as a footprint parameter? – to be allowed strictly for the earth-moving case.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSlicon | yes |  |
| Intel | no strong view | If Reference point and radius approach can be agreed, it seems not necessary to adopt another approach. |
| Ericsson |  | It seems like there are a lot of details that are assumed that we have yet to agree upon. We have for instance not even agreed to have multiple elevation angles. We would like to ask satellite operators whether there really is a use case why the satellites coverage would not be not radiating directly downwards (remember that there is no possibility of changing how the beams point or risk messing with UEs estimation algorithms). If it is the case, then we are fine to have two elevation angles. Otherwise we would prefer not to optimize and only have a single elevation angle to represent the satellite’s coverage.  |
| MediaTek | yes |  |
| ZTE | Maybe No | It’s still not clear what ambiguity would occur without such elevation angle for earth-moving case. We should try to avoid providing redundant information via SIB. |
| Qualcomm | No | On the earth surface, what the UE needs is a reference point and coverage radius of the footprint for simplicity. |
| Eutelsat | Yes | (Optional) |
| Lenovo | Yes | We prefer to use EM for moving cells rather than refencepoint+radius. |
| Nokia |  | We do not see a need for the elevation angle information if the (reference point + radius) is provided. However, use of elevation angle may result in less SI updates for the network.- If the reference point is agreed as “under nadir”, then NW may only need to indicate the radius, in this case ,there is no need to define the min elevation angle to define two mechanisms for the same purpose.- Otherwise, we think min elevation angle is better than (ref point + radius) for earth moving cell. |
| CATT | Yes | If Reference point and radius approach cannot be agreed for earth-moving case. |
| Google | Yes |  |
| Xiaomi |  | Prefer to define unified solution for earth moving cell and earth fixed cell if we decide to introduce foot print parameters for earth moving cell. |
| OPPO |  | We share the same view as Ericsson. Single elevation angle is simple if it can be confirmed that satellite coverage is always radiating directly downwards. Defining two elevation angles looks a bit complicated. |
| Inmarsat |  | No strong views – two elevation angles seems slightly redundant if we agree on reference point + radius. There are practical scenarios where a satellite with earth-moving cells would project actual coverage only on a specific area that may be anywhere on the satellite theoretical coverage, including offset to the satellite.  |
| InterDigital | Yes |  |
| Sateliot | Yes | We think that this approach is sufficient for Eart-moving cells and more efficient in terms of size than “reference point + radius” (1 byte vs 5.75 bytes) |
| Novamint | Yes |  |
| GateHouse |  | No strong opinion. |
| Hughes/EchoStar |  | No strong view |
|  |  |  |

### Summary - Question 4.6

No strong opposition. Set of elevation angles as an optional footprint parameter for the Earth-moving case should be agreeable.

## Other

### Satellite/Beam ID

A Satellite / Beam ID is suggested in R2-2206160. A satellite ID is suggested in [R2-2205143](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2205143.zip).

**Rapporteur’s proposal:**

Include an **optional** satellite / beam ID

ID:

 Range 0 to 255

 Granularity: 1
 Bits: 8

So, 8 bits or 1 byte in total.

UE behaviour on receiving a list of non-ID’d SAI:

1. Discard all prior SAI (both non-ID’d and ID’d) and only keep the new non-ID’d SAI.
2. Discard all prior non-ID’d SAI and keep the new non-ID’d SAI along with any ID’d SAI.
3. Add the new non-ID’d SAI to the set of known SAI. It is up to UE implementation to discard old SAI.

UE behaviour on receiving ID’d SAI:

1. Discard all prior SAI (both non-ID’d and ID’d) and only keep the new ID’d SAI.
2. Discard all prior non-ID’d SAI and keep the new non-ID’d SAI along with any ID’d SAI.
3. Add the new non-ID’d SAI to the set of known SAI. It is up to UE implementation to discard old SAI.

**Question 4.7: Do you support an optional ID for satellites / beams as specified above? Please list your prioritization of the associated UE behaviour.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Example | Yes | We support an optional ID for both satellites (earth-moving scenario) and beams (earth-fixed scenario).Priorities: (C, B, A) and (F, E, D) |
| Huawei, HiSilicon |  | is the satellite ID only applicable to early fixed scenario as in R2-2206160 ?Globally, it is not clear to us the usage of the satellite ID. The reason is that, normally, delta configuration does not apply to broadcast signalling. i.e. the new contents of the SIB replaces the old contents (options A, D). However, the proposals here B.C, E, F seem to suggest otherwise |
| Intel | F | not clear in which scenario there is a non-ID’d SAI. |
| Ericsson | No | **We do not prefer to have optimizations at this point.** We prefer to signal satellite ID to identify the ephemeris/coverage of a satellite and that it is up to UE implementation how to process this information so we do not quite agree to the behaviour above. Huawei has a good point about delta configuration in broadcast signalling and we need to think about how to deal with this.  |
| MediaTek | Yes | Support satellite operators. Options (C) and (F) seems the best. |
| ZTE | Maybe No | Even we have mentioned a global satellite ID with one byte length in our contribution [R2-2205143], we are also not clear about the usage of such satellite ID.We agree with Huawei’s comments that, in legacy IoT, we support neither delta configuration in SIB nor concatenation of multiple identical SIBXs. From this perspective, a global satellite ID seems not useful.Is there any intention to support SIB segmentation in RRC layer? (as in IoT, the SIB size is limited so that not much satellites’ assistant information can be provided.). However, we hope this would not be supported in R17 as this may need many changes and have impacts on SIB change notification/SIB update procedure. |
| Qualcomm | Yes but | It is easy to refer and associate with neighbor cell list.Can’t the satellite ID be unique for a given PLMN? The UE should be able to store the valid ID of the valid ephemeris.If same satellite ID is broadcast, then off course the UE will replace it. |
| Eutelsat | See comments | At least for moving beams in Rel-17, we prefer always having an explicit satellite ID associated to each ephemeris set as:- benefits of not indicating a Sat Id are not obvious- pros and cons of the different options that would be resulting from not indicating a sat Id would have to be further evaluated. |
| Lenovo | Yes with comments | We can accept satellite IDs to be added, but if IDs can be associated to cells/cell list, then it is not necessary. |
| Nokia | Yes | We prefer to leave the handling of SAI to UE implementation (options C and F).  |
| CATT | Yes with comments | Have the same view with Lenovo. |
| Google | No | Prefer to not optimize this aspect (delta signalling for the broadcast configuration?) at this point.  |
| Xiaomi | See comments | We are not clear why the Satellite ID is needed since the cell id can be used to identify the neighbour cells.  |
| OPPO | Yes for the satellite IDFFS for the UE behaviour | In our understanding, the global satellite ID is always needed for earth moving cell, but for earth-fixed cell, satellite ID is not needed since it only broadcasts the start time of the next satellite. |
| Inmarsat | Not sure | We have a similar impression as Ericsson and Eutelsat, it’s not fully clear what happens if this is optional and thus potentially not signalled. A baseline value should allow implicit or explicit correlation of the ID value to either satellite (as a minimum) or beam ID within a satellite coverage.As for the options, C and F seems most reasonable. This should apply to both earth-fixed and earth-moving cases. |
| InterDigital | Yes | OK to include ID. The processing/storage can be left to UE implementation – default is that UE just stores the latest received SIB but it is also possible for UE to maintain a longer list of IDs internally. |
| Sateliot | Yes | “Satellite ID” is a necessary parameter to have when “SGP4 ephemeris” are used. For instance, when a UE decodes the “SGP4 ephemeris” broadcast in a SIB, the UE should know to which satellite the received SGP4 ephemeris corresponds to, so that the UE can refresh previous ephemeris of the same satellite and keep track of {satellite ID, SGP4 ephemeris} |
| Novamint | Yes | Considering the satellite operators comments, we support to have a “Satellite ID” |
| GateHouse | Yes | The Satellite ID is important. Option C and F preferred. |
| Hughes/EchoStar | Yes | Prefer C and F |

### Summary - Question 4.7

12 in favor, 6 against: Support larger for earth-moving case.

Proposal: Either

1. We allow SatelliteID as an optional parameter for the earth-moving scenario
	1. And define that it is up to UE implementation to keep track of known satellites, ie. delta-configuration is allowed.
	2. And define that the UE and CN will expect paging to take place when the UE is in coverage of the satellite that was transmitted in SIB32 by the last known servicing satellite.
2. We do not look at this capability before rel-18 - restricting UEs to not voluntarily gather info: Resulting in fewer MO opportunities for the UE.

### Validity duration for satellite Epoch

[R2-2205143](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2205143.zip) suggests to have a validity duration for the earth-moving case in the order of minutes.

“… Moreover, during email discussion, companies mentioned the observation that the epoch times of the ephemeris information sent for different satellites is unlikely to coincide. Each advertised satellite will come with its own epoch time, which only indicates the time at which the TLE was determined.”

The rapporteur points out that the EPOCH is not the time at which a TLE is determined – it is the time at which the TLE was determined for, i.e., the EPOCH can lie in the future. The TLE is most accurate around the EPOCH. Creating and assessing TLEs with EPOCHs in the future involves sampling the future orbit of the satellite using numerical integration methods, which are extremely accurate.

**Question 4.8: Do you support a validity duration parameter should be included as an optional parameter in SIB32?**

1. If so, please remark on the range and granularity of the validity duration?

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilicon | FFS | We assume that the ephemeris will be updated before they become too inaccurate and that these updates will not be frequent (i.e stay accurate for several hours)so either updates are notified by the system information update procedure (see 4.9), and there is no need for a validitity time.Or the system information procedure is not used and an information on how long the UE can consider the information accurate is needed |
| Ericsson | No | We think there should not be a reported validity duration for the mean ephemeris. It is up to UE implementation. |
| MediaTek | No strong view |  |
| ZTE | Maybe No | We have similar view as Huawei and slightly prefer that network can trigger the legacy update procedure of SIB32 in time and the network may not need to provide the validity duration for each satellite.If validity duration is absent for a satellite, UE can assume this satellite is always valid till it’s updated. |
| Qualcomm | Yes | But default value has to be assumed if not provided, for example, a week based on SGP-4 epoch time. |
| Eutelsat | No | - Network should update ephemeris frequently enough so that a fresh-enough set should be available to the UEs- A UE should be able to estimate a wakeup time accuracy based on the used propagator type (here SGP4) and on the horizon of the computed wakeup. The UE can move the wakeup forward to compensate for the inaccuracy |
| Lenovo | FFS | If the validity time of mean ephemeris can be very long (e.g. weeks), we think it may not be necessary to have a validity time as NW will update it in time. |
| Nokia | No | Given the expected long validity of TLE it does not seem useful to complement the SAI with a validity duration. It may be sufficient to have some pre-defined values on the duration in specification. |
| CATT | No strong view | If included, the validity duration can be defined with a coarse granularity, like minute, ten minutes or hour.  |
| Google | No | Updating SIB32 does not occur frequently and hence the optimization is not that critical (can be moved to Rel-18). |
| Xiaomi | No | The mean ephemeris data will not be changed frequently, if network update the ephemeris data, the system information modification procedure is used. So the validity duration is not needed. |
| OPPO | Yes | Agree with Qualcomm. The validity duration with a default value is needed.The validity duration needs to be considered together with the handling of the SIB32 update. From the UE side, if relying on the legacy SI modification procedure, when the eNB pages UE for SI modification to update the expired ephemeris orbital parameters and epoch time, UE may have already left the coverage of this eNB and cannot update the related ephemeris orbital parameters and epoch time, since an earth-moving cell usually has very short service time for a certain UE.In our understanding, UE autonomously obtains the related ephemeris parameters and epoch time broadcasted in SIB32, and the validity duration is still needed for this. |
| Inmarsat | Unclear – please see comment | This is more about validity of the Ephemeris in respect to Epoch, rather than the Epoch value itself, right? Epoch is a time instant value so it’s unclear how it can have a “validity”? We also share rapporteur’s point of view that Epoch time is time instant **for** which a TLE is determined, not **at**. At present the only scenario we can think of that would benefit from an explicit validity period is if the satellite has a manoeuvre planned that would change the satellite orbit so in a way signalling it to the UE in advance is required to avoid the UE going to sleep and possibly missing the next pass. However, it should be noted that this is a corner case because if somehow the satellite happens to have to perform an unplanned course change at a later stage, it would affect the implicit (propagated) or explicit (signalled) validity regardless. |
| InterDigital | No strong view | Even if we do not specify an explicit validity time, the system information is in general subject to a validity time as per legacy. |
| Sateliot | No strong view | If not included, the decision for how long a UE may keep using an old SGP4 ephemeris (and not refreshing it with new ones provided by the network) is just left to UE implementation. If a validity duration parameter was included, it is our understanding that it could be used by the network to force UEs to refresh ephemeris information.  |
| Novamint | No strong view |  |
| GateHouse |  | No strong opinion. |

### Summary - Question 4.8

2 in favor, 3 FFS, 5 against, 6 undecided.

Rapporteur proposal:

An effective way forward could be to assume that a new SIB32 update will be provided to the UE before the SGP4 parameters become too imprecise: Meaning before the In-track propagation error grows beyond |100|km.

Once SIB32 predictions fail a UE can trigger RLF.

Furthermore, R2-2205143 suggests using legacy notification procedure to signal changes in SIB32.

**Question 4.9: Should we define a, b, c or d?**

1. **UEs to only read SIB32 if changes are signalled by legacy procedure ie. in MIB. to save power?**
2. **UEs read SIB32 upon wake-up, but otherwise only if changes are signalled by legacy procedure**
3. **Up to UE implementation. Changes to SIB32 can be signalled by legacy procedure.**
4. **Nothing.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilicon | FFS | see answer to Q4.8 |
| Ericsson | Not clear on the options | There is no need to indicate changes in SIB32. Addition or removal of satellites from the list does not affect UEs which already acquired SI.We expect that a UE should wake up regularly to detect paging etc.  |
| MediaTek | No | Not needed at this point. |
| ZTE | b | See answer to Q4.8. We just assume this is same as some legacy SIBs, e.g., SIB3~SIB5. |
| Qualcomm |  | Isn’t there validity duration, Be it the signaled one or default one? |
| Eutelsat | See comment | IoT UEs would read SIB 32 at wakeup time and acquire ephemeris for predicting their next wakeup time before (e.g.) proceeding to data transmission then going back to deep sleep. As mentioned by Ericsson, MediaTek, there seems no need to indicate change to this SIB. |
| Lenovo | FFS | Not quite sure about the necessity. Could be UE implementation. |
| Nokia | See comments | Changes to SIB32 should be excluded from legacy “SI change” procedure. As a satellite passes over an area the content of SIB32 will change to reflect that different future satellites will cover the different parts of the area. In our understanding, it can be left to UE implementation to ensure they obtain the SIB32 during the time the satellite provides service to the UE. |
| CATT | b |  |
| Google | c | It can be left to UE implementation in Rel-17. |
| Xiaomi | C  | We are not clear why we need specify the UE behaviour for reading SIB32.  |
| OPPO | No | As we stated in Q4.8, The validity duration needs to be considered together with the handling of the SIB32 update. In our understanding, UE autonomously obtains the related ephemeris parameters and epoch time broadcasted in SIB32 after validity timer expires, and the validity duration is still needed. |
| Inmarsat | B  | B seems more reasonable. |
| InterDigital | d | UE shall read system information upon validity timer expiry and when NW triggers SI modification. This is covered in legacy procedure which will automatically apply to any new SIB, or would be additionally covered should be introduce a dedicated validity timer for this SIB.The question is really whether to specify that the contents can be modified without triggering SI modification procedure  |
| Sateliot | See comment | Agree with Nokia comment that it can be left to UE implementation to ensure they obtain the SIB32 during the time the satellite provides service to the UE. |
| Novamint | Not clear on the options |  |
| GateHouse |  | Option C – to be decided by UE implementation. |
| Hughes/EchoStar |  | Option C |

### Other

**Question 4.9: Feel free to raise any other points – any additional parameters or behaviour that is essential for discontinuous coverage in Rel-17 that has not been considered.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Ericsson |  | In 36.304 we have the following editor’s note: Editor's Note: FFS which parameters may be used for determining out of coverage and how network can configure that a UE may determine that it is out of coverage, i.e. through configuring SIB32 or not.We think that a UE may **only** use discontinuous coverage if SIB32 is signalled, otherwise the UE shall not be allowed to sleep.  |
| ZTE |  | Can agree with Ericsson for the mentioned issue. |
| Nokia |  | The proposed SAI is useful, but also leads to a large payload (EFC example): 205 (SGP4) + 20 (t-ServiceStart-r17) + 46 (reference point + radius) + 8 (satellite/beam ID) = 279 bits.NB-IoT has a maximum SIB size of 680 bits i.e. just 2 sets of SAI can fit. There may be a need for RAN2 to investigate segmentation of the SIB32 |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

### Summary - Question 4.9

Rappeteur thinks Ericsson’s proposal should be agreed. A UE is in discontinous coverage mode if SIB32 is signalled.

Nokia: There is some misconception here, the earth-fixed and earth-moving parameters should not be mixed.

Earth-moving: 188 (SGP4, removed numEpochs) + 8 (satID)+ 8 (Radius/elevationangles) = 204 bits

Earth-fixed: 20 (t-ServiceStart-r17) + 46 (Ref+radius) = 66 bits

So, for NB-IoT TBS of 680 there should be space for SAI for 3 satellite’s in the Earth-Moving case and up to 10 beams in the earth-fixed case.

# ASN1 proposals (TN)

 The following structure is based on an acceptance of all proposals of R2-2206160.

|  |
| --- |
| -- ASN1STARTSystemInformationBlockType32-r17 ::= SEQUENCE { satelliteInfoList-r17 SatelliteInfoList-r17 OPTIONAL, -- Need OR nonCriticalExtension SEQUENCE {} OPTIONAL, ...}SatelliteInfoList-r17 ::= SEQUENCE (SIZE (1..maxSat-r17)) OF SatelliteInfo-r17SatelliteInfo-r17 ::= SEQUENCE { satelliteSAI-r17 CHOICE { sgp4EphemerisParameters-r17 SGP4EphemerisParameters-r17  earthFixedCellParameters-r17 EarthFixedCellParameters-r17 nonCriticalExtension SEQUENCE {}  } satelliteID-r17 INTEGER (0..255) OPTIONAL, satelliteFootprintParameters-r17 SatelliteFootprintParameters-r17 OPTIONAL, nonCriticalExtension SEQUENCE {} OPTIONAL,} EarthFixedCellParameters-r17 ::= SEQUENCE { t-ServiceStart-r17 SEQUENCE( SIZE (1..10)) OF INTEGER (0..1048575) nonCriticalExtension SEQUENCE {}}SGP4EphemerisParameters-r17 ::= SEQUENCE { inclination-r17 INTEGER (0..2097151) periapsis-r17 INTEGER (0..2097151) longitude-r17 INTEGER (0..4194303) anomaly-r17 INTEGER (0..4194303) eccentricity-r17 INTEGER (0..16777215) meanMotion-r17 INTEGER (0..17179869183) revNoEpoch-r17 INTEGER (0..131071) bStar-r17 BIT STRING (23) epochStar-r17 INTEGER (-1048575..1048575)} SatelliteFootprintParameters-r17 ::= SEQUENCE { elevationAngleR-r17 INTEGER (-7..7) OPTIONAL, elevationAngleL-r17 INTEGER (-7..7) OPTIONAL, refPointX-r17 INTEGER (X1..X2) OPTIONAL, refPointY-r17 INTEGER (Y1..-Y2) OPTIONAL, refRadius-r17 INTEGER (1..200) OPTIONAL, nonCriticalExtension SEQUENCE {} OPTIONAL,}-- ASN1STOP |

**Question 5.1: Please provide views on the above ASN.1 specifications structure without regard to the parameters, which are to be discussed in section 4. Are you okay with:**

1. SAI type as a CHOICE per satellite/beam.
2. earthFixedParameters-r17 SEQUENCE to hold parameters for the EF scenario – to ensure extensibility.
3. EF parameters as a list of parameters (timestamps) instead of a single instance (single timestamp).

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilicon |  | it is possible to have mix deployment, earth fixed and earth moving ? if no, the CHOICE would be better moved out of the satelliteInfo element. i.e. provided at the list levelOn ASN.1 aspect, nonCriticalExtension cannot be used in sub-element, extension marker ‘…’ are used instead.However, extension markers are not recommended in element of a list due to the ‘multiplied’ signalling overhead. Instead when extension are needed, parallel are created. In summary, only the top level nonCriticalExtension and extension marker ‘…’ should be kept. Other pure ASN1 details, e.g. Need Code, can be sorted out by the CR rapporteur  |
| Ericsson |  |  36.331 rapporteur can implement it according to the agreements later. The above excerpt needs some re-working. a. We have so far only been talking about satellite coverage and not beam coverage. We do not want this optimization. c. Discussed above, but we prefer not to do this optimization at this point. |
| MediaTek | Yes, but | Agree in principle. The details could be implemented by 36.331 rapporteur |
| Qualcomm |  | Let the rapporteur handle this.  |
| Lenovo |  | Discuss in 36.331 implementation. |
| Nokia |  | The ASN.1 provided before question 4.4 included also ephemerisOrbitalParameters. It will be beneficial if that is excluded as also proposed in the above proposal for question 5.1. |
| CATT | No |  |
| Google |  | We are fine with the first bullet (a), but think the details/implementation can be handled by the rapporteur after the discussions above are concluded. |
| OPPO |  | Let the rapporteur handle this. |
| Inmarsat |  | No strong views on the above, but as a separate comment, do we need to specify the parameters group to explicitly relate to SGP4?i.e. SGP4EphemerisParameters-r17What about cases that require SDP4 (e.g. MEO, possibly HEO which also uses SDP4) or other propagators but use the same input parameter set? |
| Sateliot | Yes, but | Agree with the general approach and with the proposal from many companies that details could be implemented by 36.331 rapporteur.On Inmarsat point about SGP4/SDP4, one possibility could be to rename “SGP4EphemerisParameters-r17” to “TLEEphemerisParameters-r17” |
| Novamint | Yes  | Agree in principle. Sateliot’s suggestion about SGP4/SDP4 acceptable for us. |
|  |  |  |

### Summary - Question 4.9

Will leave details up to 36.331 Rapporteur

# Conclusion

 **Table 2**. SGP4 parameters: Units, range, bit size and granularity.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameter | Unit | Range | Min states | Nearest Bit | States | Granularity |
| *Example* | *SI* | *X to Y* | *Smin* | *B =* ⌈log2*(Smin)*⌉ | *S = 2B* | *(Y-X)/(S-1)* |
| Inclination | Deg | 0 to 180.0000 | 1800001 | 21 | 221 | 8.583073616e-5 |
| Arg of Perigee | Deg | 0 to 180.0000 | 1800001 | 21 | 221 | 8.583073616e-5 |
| right ascension of ascending node | Deg | 0 to 360.0000 | 3600001 | 22 | 222 | 8.5830712318e-5 |
| Mean Anomaly | Deg | 0 to 360.0000 | 3600001 | 22 | 222 | 8.5830712318e-5 |
| Eccentricity | - | 0 to .9999999 | 1e+7 | 24 | 224 | 5.96046388e-8 |
| Mean Motion  | rev/day | 0 to 99.99999999 | 1e+10 | 34 | 234 | 5.82076609e-9 |
| B\* decimal |  (earth radii)-1 | -.99999 to .99999  | 199999 | 18 | 218 | 0.00001 |
| B\* exponent | - | -9 to 9 | 19 | 5 | 25 | 1 |
| Epoch\* | sec | -1048575 to 1048575 | 221 - 1 | 21 | 221 | 1 |

Notes:

1. B\* is found by taking ‘B\* exponent’ as the exponent of ‘B\* decimal’.
2. The granularity of the number of revolutions should be the integer 1 so the range has been extended from the TLE formats maximum of 99999 to 131071.
3. The variables, ”*Inclination, Arg of Perigee, Right Ascension of the Node, Mean Anomaly, Eccentricity and Mean Motion*“ all have slightly improved granularities compared to TLEs due to “extra” states being introduced when per-parameter encoding is introduced in contrast to TLEs character encoding.
4. The variable Epoch\* is a time offset between the beginning of the current week and the SGP4 Epoch.
5. Epoch\* defines the offset to the actual Epoch and is limited to a range of +/- 1048575 seconds (+/- ~12.1 days) referenced at the start of the current week (Monday 00:00:00 UTC).
6. It is reasonable that a new ephemeris is available before the old ephemeris (and any propagations) becomes too inaccurate. In the (unlikely) case that SGP4 ephemerides have Epochs that lay outside of this range, those can reasonably be propagated to the current week before being broadcast. Propagated ephemerides neither gain nor loose accuracy compared to the original ephemerides.
7. Since the SAI is for aiding UEs to predict coverage in the DC scenario a granularity of 1 sec is very reasonable as the added energy consumption for a UE to wake up approximately half a second in advance of predicted coverage (excluding prediction error over time) is negligible.

Total: 188 bits, 23.5 Bytes.

 **Table 3**

|  |
| --- |
| Reference frame: WGS 84Reference coordinates: Longitude and Latitude Range: 180.000 to 180.000 Granularity: 0.00068664681 Deg (< 100 meter on Earth’s surface) Bits: 19 x2Radius: Range 10 to 2560 km Granularity: 10 km. Bits: 8 |
| So 46 bits in total, or 5.75 Bytes. |

 **Table 4**

|  |
| --- |
| Reference point: Associated SGP4 satelliteElevation angles: Range -70 to 70 Deg Granularity: 10 Deg Bits: 4 x2 |
| So 8 bits in total. |

 **Table 5**

|  |
| --- |
| Reference point: Associated SGP4 satelliteRadius: Range 10 to 2560 km Granularity: 10 km. Bits: 8 |
| So 8 bits in total. |

## Proposals

### Agreeable

* **Proposal 1: The reference frame for SGP4 propagator and SGP4 parameter generation is TEME as per the NORAD Space Track standard.**
* **Proposal 2: Define SGP4 parameters according to table 2.**
(Attention: Rapporteur removed number of revolutions at epoch)

### Short discussion

There is consensus for the two following proposals – but both require the UE to have a UTC time reference - it is a matter of whether companies agree that UEs will have the UTC reference from onboard GNSS or SIB16 needs to be transmitted.

* **Proposal 3: UEs should obtain an UTC reference via SIB16/GNSS**

### Agreeable

* **Proposal 4: Define the Epoch parameter as a time offset between the beginning of the current week and the actual SGP4 Epoch****. Range of +/- 1048575 seconds and granularity of 1 sec.**
* **Proposal 5: Define the t-serviceStart-r17 parameter as a time-offset since the beginning of the current week. Range of 0 to 1048575 seconds and granularity of 1 sec. ASN.1 type: “INTEGER (0..1048575)”**
* **Proposal 6: Define “reference point and radius” as optional footprint parameter for Earth-fixed cell case: See table 3.**
* **Proposal 6: Define “elevation angles” and “radius” as optional footprint parameter for Earth-moving cell case: See table 4 and table 5.**

### Likely agreeable:

* **Proposal 7: An effective way forward could be to assume that a new SIB32 update will be provided to the UE before the SGP4 parameters become too imprecise: Meaning before the In-track propagation error grows beyond |100|km.**
* **Proposal 8: A UE can only go in discontinuous coverage state if SIB32 is received.**

### Likely require discussion:

* **Proposal 9: On the topic of satellite ID :**
1. **We allow SatelliteID as an optional parameter for the earth-moving scenario**
	1. **And define that it is up to UE implementation to keep track of known satellites, ie. delta-configuration is allowed.**
	2. **And define that the UE and CN will expect paging to take place when the UE is in coverage of the satellite that was transmitted in SIB32 by the last known servicing satellite.**
2. **We do not look at this capability before rel-18 - restricting UEs to not voluntarily gather info: Resulting in fewer MO opportunities for the UE.**

## Essential synchronisation of companies?

|  |
| --- |
| **It seems that companies have very different ideas about how the discontinuous coverage feature is targeted to work in r-17, which may lead to misunderstandings. We should seek alignment:****Rapporteurs understanding underneath:****SIB32 is used for predicting coverage. (Discontinuous coverage case)*** UE is in discontinuous coverage scenario as soon as it detects a SIB32.

**UEs in discontinuous coverage are not required to perform cell search etc.*** PSM can be used for UEs out of coverage (in discontinuous coverage scenario)

**Coverage prediction*** SGP4 for Earth moving cells
* Service time start for Earth fixed cells
* Satellite footprint parameters for

 RefPoint (Earth fixed) Radius (EF/EM) ElevationAngles (EM)**Up to UE implementation to wake-up in advance of coverage.**Upon wake-up:* **UE does not do TAU if one of the currently broadcasted TAC belongs to UE’s registration area.**
* While in coverage, function as a normal UE – IE. paging opportunities are configured and observed as usual. When going from non-coverage to coverage state:
* Determine frame number of cell
* Perform iDRX while in-coverage (observe Paging Frame + Paging Occasion)
* Read SIB32

**UE in discontinuous coverage case may attempt cell search for emergency calls, etc. regardless of being in “non-coverage”-state.** |

# References

1. [R2-2205933](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2205933.zip) "Email Discussion Report [Post117-e][906][IoT-NTN] Non-Continuous Converge”, MediaTek Inc.

1. [R2-2206160](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2206160.zip) “ASN.1 proposal for satellite assistance information for prediction of discontinuous coverage”, Sateliot, GateHouse, Mediatek, ESA, Eutelsat, Hispasat, Hughes/Echostar, Inmarsat, Ligado, Novamint, Omnispace,
2. [R2-2205598](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2205598.zip) “Assistance Information for Predicting the Discontinuous Coverage”, Google Inc.
3. [R2-2205143](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2205143.zip) “FFS and RILZ302, H000, O302 etc for SIB32”, ZTE Corporation, Sanechips

1. [R2#118-e](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Inbox/Chairs_Notes/R2_118-e%20Chair%20Notes%202022-05-10%200600%20UTC.docx) “Monday online session, chair’s notes”