3GPP TSG-RAN WG4 Meeting #116 R4-2512525

**Bengaluru, India, August 25 – 29, 2025**

**Agenda item:** 7.6.1

**Source:** Samsung

**Title:** Way Forward for [116][323] NTN\_testing\_NGSO\_channel\_model\_and\_demod

**Document for:** Approval

# Introduction

This t-doc provides WF for [116][323] NTN\_testing\_NGSO\_channel\_model\_and\_demod.

# WF

## Sub-topic 1-1 TE emulated channel model for satellite mobility

**Issue 1-1-1  FFS whether and how to consider the propagation delay model for UL delay error for RRM uplink timing error cases**

* agreement
  + RAN4 should specify the UL propagation model for UE delay error as

Where

SV (Satellite) : Receiver

UE : Transmitter

: Uplink total propagation delay

*tT*  : Time when signals are transmitted from UE

*tR*  : Time when signals are received by satellite

: SV position vector on ECI Frame at *tT*.

: UE position vector on ECI Frame at *tT*.

***V***SV : Satellite velocity vector on ECI Frame

:Distance between satellite and UE.

*c* = 2.99792458 x 108 [m/s]

* + ~~[~~Note: It is not mandated that UE follows this formula for UL propagation delay estimation~~]~~

**Issue 1-1-2 Initial ephemeris information for LEO-600 satellite**

* agreement
  + Set the initial ephemeris information for LEO-600 with (positionX, positionY, positionZ, velocityVX, velocityVY, velocityVZ) = (-2654249, 4386991, 1594205, 14581, -34487, 120182), which corresponds to (-3450.5237 km, 5703.0883 km, 2072.4665 km, 0.87486 km/s, -2.06922 km/s, 7.21092 km/s), related with the initial elevation angle of 30 degrees

## Sub-topic 1-2 RAN4 requirements

**Issue 2-1-1 AoA (Ө) value setting for fading channel simulation**

* agreement
  + Use cos(Ө) = 0.7 (Same as Rel-17 NTN and Rel-18 IoT-NTN UE demodulation simulation assumptions) to run simulations when using time varying Doppler shift and propagation delay model for NTN LOS channel.

**Issue 2-1-2 NR NTN demodulation requirement with applying time-varying channel model**

* agreement
  + Introduce an additional margin of 0.5 dB to the Rel-17 NR NTN UE demodulation performance requirements

**Issue 2-1-3 IoT NTN demodulation requirement with applying time-varying channel model**

* agreement
  + RAN4 can take the residual frequency offset as 200Hz and time offset error as to check the demodulation requirement impact with applying time-varying doppler shift and propagation delay channel model for IoT NTN
    - For Category M1
* Table 7.24A.2-1: Te\_NTN\_M1 Timing Error Limit (TS 36.133)

|  |  |
| --- | --- |
| CE Mode | Te\_NTN\_M1\_ |
| A | 41\*TS (=1.33 us) |
| Note 1: TS is the basic timing unit defined in TS 36.211 4.1.  Note 2: This requirement applies regardless of the downlink carrier bandwidth. | |

* + - For NB-IoT
* Table 7.20A.2-1: Te Timing Error Limit (TS 36.133)

|  |  |
| --- | --- |
| Downlink Bandwidth (MHz) | Te\_ |
| 0.18 | 97\*TS (=3.16us) |
| Note 1: TS is the basic timing unit defined in TS 36.211 4.1 | |

* + Further discuss whether to add the additional margin based on simulation results in the next meeting

**Issue 2-1-4 Sampling frequency offset impact for testing**

* agreement
  + Interesting companies including UE and TE vendors are encouraged to provide analysis and evaluation for the impact of sampling frequency offset in related to both the Doppler frequency and its rate of change (i.e., Doppler drift) caused by satellite motion.
  + FFS how and where to capture the impact of sapling frequency offset if identified

**Issue 2-1-5 Test applicability of requirement with applying time-varying channel model**

* WF
  + Option 1:
    - The satellite motion-based time varying channel model can be retroactively applied to pre-Rel-19 test cases subject to DUT declaration.
  + Option 2
    - For Rel-19 UE, if UE can pass new NGSO requirements applying the new channel model, then it can skip all NGSO requirements defined in Rel-17/Rel-18.
    - For Rel-17/Rel-18 UE, if UE can pass new NGSO requirements applying the new channel model, then it can skip all NGSO requirements defined in Rel-17/Rel-18.
  + Other options are not precluded

## Sub-topic 1-3 CR work split

* agreement

|  |  |  |
| --- | --- | --- |
| Spec | Section | Company |
| Big CR for 38.101-5 |  | Samsung |
| Big CR for 36.102 |  | Samsung |
| LS to RAN5 |  | Samsung |
| 38.101-5 | New Annex Channel model (including the accuracy) | Anritsu Corporation |
| 8.2.1.2, PDSCH demodulation requirement | QC |
| A.4 Testing related to Satellite Access | Huawei |
| Applicability of requirements |
| 36.102 | New Annex Channel model (including the accuracy) | Anritsu Corporation |
| 8.2 Demodulation performance requirements for UE category M1 | Ericsson |
| 8.3 Demodulation performance requirements for UE category NB1 and NB2 |
| A.3 Testing related to Satellite Access | MTK |
| Applicability of requirements |

* + Companies are encouraged to provide the draft CR in RAN4#116bis.

# Reference

[1] R4-2511468, “Topic summary for [116][323] NTN\_testing\_NGSO\_channel\_model\_and\_demod “, Moderator (Samsung)

# Appendix (for information)

## A.1 Satellite position/velocity estimation

**Input values:**

|  |  |  |
| --- | --- | --- |
| Parameters | Unit | Description |
|  | km | Initial satellite position state vector at time 0 in Earth-centered earth-fixed frame (ECEF) |
|  | km/s | Initial satellite velocity state vector at time 0 in Earth-centered earth-fixed frame (ECEF) |
|  | second | Time to derive the satellite position and velocity |

**Output values:**

|  |  |  |
| --- | --- | --- |
| Parameters | Unit | Description |
|  | km | Satellite position state vector at time *t* in Earth-centered earth-fixed frame (ECEF) |
|  | km/s | Satellite velocity state vector at time *t* in Earth-centered earth-fixed frame (ECEF) |

**Constant parameters:**

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | Description | Values | Unit |
|  | Gravitational parameter for Earth | 3.986004418 x 105 | km2/s2 |
|  | Earth angular speed | 7.2921151467 x 10-5 | rad/s |

### A.1.1 Keplerian model based estimation

#### Step 1 Derive the orbital parameters (a, e, i, Ω, ω, M0)

##### Step 1-0 Convert the initial position/velocity state vectors from ECEF format to ECI format

Note we assume the x-axis of ECI and ECEF the same for simplicity.

##### Step 1-1 Position magnitude (r), velocity magnitude (v), and orbital angular momentum (h)

##### Step 1-2 Inclination (INC, i)

Note the range of INC is between 0 and π (radian).

##### Step 1-3 Right Ascension of the Ascending Node (RAN, Ω)

Note the range of RAN is between 0 and 2π (radian).

Note Ω is called as ‘Longitude of ascending node’ in TS 38.331 *ephemerisInfo-*r17.

##### Step 1-4 Eccentricity (ECC, e), Semi-major axis (SMA, a), Period (P)

Period of the satellite around earth, *P* (sec), is given by:

##### Step 1-5 Argument of Periapsis (AP, ω)

Note the range of AP is between 0 and 2π (radian).

##### Step 1-6 Mean Anomaly at time 0 (MA, M0)

True Anomaly at time 0 (ν0):

Eccentric Anomaly at time 0 (E0):

Mean Anomaly at time 0 (M0):

Note the range of M0 is between 0 and 2π (radian).

#### Step 2 Determine the satellite position and velocity at time t (sec)

##### Step 2-1 Mean Anomaly at time *t* (Mt):

##### Step 2-2 Derive Eccentric Anomaly at timet (Et) by solving Kepler’s equation with Newton’s method

Build the Kepler’s equation between Mt and Et:

**Step 2-2-1:** Set

**Step 2-2-2:** Calculate

**Step 2-2-3:** Calculate

**Step 2-2-4:** Update from , , and , as follows:

**Step 2-2-5:** If , then set and go to Step 2-3. Otherwise, go to Step 2-2-2 by setting n := n+1.

Note , for example.

Note n=0, 1, 2, …

##### Step 2-3 Derive True Anomaly at time *t* (νt)

Note the range of νt is between 0 and 2π (radian).

##### Step 2-4 Convert the orbital elements to the state vector in ECI frame

Convert to the state vector in perifocal frame,

Convert the state vector from perifocal frame to ECI.

Convert the state vector from ECI to ECEF.

### A.1.2 Equation of Motion based estimation

##### Step 1: Initialization

Set time step size of position/velocity updates. Set (sec), for example, if the satellite position/velocity is updated every 1 second.

##### Step 2 Solve the equation of motion with the 4th-order Runge-Kutta method.

Where

##### Step 3: Determine the satellite position/velocity at time *t*.

If :

Otherwise, set , and go to Step 1.

## A.2 Varying Doppler shift and propagation delay generation

### A.2.1 Determine UE position

This step calculates the UE position according to the earth angular speed. Since the UE location is configured with a format of latitude, longitude, and altitude, we need to convert the values to ECEF format to align with the satellite position/velocity state vectors.

**Input values:**

|  |  |  |
| --- | --- | --- |
| Parameters | Unit | Description |
|  | degree | Initial UE latitude |
|  | degree | Initial UE longitude |
|  | km | Initial UE altitude |

**Output values:**

|  |  |  |
| --- | --- | --- |
| Parameters | Unit | Description |
|  | km | UE position state vector at time t in Earth-centered earth-fixed frame (ECEF) |

**Constant parameters:**

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | Description | Values | Unit |
|  | Earth radius | 6378.137 | km |
|  | Square of Earth eccentricity | 6.6943799014 x 10-3 |  |

Since it is assumed that UE is stationary during the tests, UE position does not change regardless of time *t*.

### A.2.2 Doppler shift and propagation delay

This step calculates the Doppler shift and propagation delay based on the satellite position/velocity and UE position state vectors calculated in the earlier steps.

**Input values:**

|  |  |  |
| --- | --- | --- |
| Parameters | Unit | Description |
|  | km | UE position state vector at time *t* in Earth-centered earth-fixed frame (ECEF) |
|  | km | Satellite position state vector at time *t* in Earth-centered earth-fixed frame (ECEF) |
|  | km/s | Satellite velocity state vector at time *t* in Earth-centered earth-fixed frame (ECEF) |
|  | Hz | Carrier frequency (e.g., 2.0 x 109 for band n256) |

**Output values:**

|  |  |  |
| --- | --- | --- |
| Parameters | Unit | Description |
|  | Hz | Doppler shift at time *t* |
|  | sec | Downlink propagation delay at time *t* |
|  | sec | Uplink propagation delay at time t |

**Constant parameters:**

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | Description | Example of values | Unit |
|  | Speed of light | 299792.458 | km/s |

Note is the reception time at UE.

Note is the transmission time at UE.

### A.2.3 Elevation angle and Azimuth angle (for information)

Additionally, the elevation angle, El (degrees), of the satellite position from the UE viewpoint at time t can be derived as follows:

Note , , and are the unit vectors for east, north, and zenith direction at the UE position at time t.

Azimuth angle, Az (degrees), is also derived as follows.

## UE location (TS 38.508-1)

|  |
| --- |
| 5.6.1 UE location UE shall determine its location during the test using any of the following means.  1. UE location for the test shall be provided to the UE via pre-configured means. During the test the UE location is not expected to change unless explicitly stated as a requirement for the test.  2. Other options such as providing UE location via AT command are not precluded.  UE location provided to the UE before the start of the test is as follows for RF Tx/Rx and DEMOD test cases for both GSO and NGSO config is as follows:  Longitude: 121.56076999  Latitude: 25.08439333 (NGSO satellites), 55.0 (GSO satellites)  Altitude: 0 |