**3GPP TSG-RAN2 Meeting #117-e *R2-220xxxx***

**Online,** **21 February- 3 March 2022**

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| *CR-Form-v12.1* |
| **CHANGE REQUEST** |
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|  | **38.305** | **CR** | **CRNum** | **rev** | **-** | **Current version:** | **16.7.0** |  |
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| *For* [***HELP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* |
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| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network | **X** | Core Network | **X** |

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|  |
| ***Title:***  | Running CR of 38.305 for Positioning WI on GNSS Positioning Integrity |
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| ***Source to WG:*** | InterDigital Inc |
| ***Source to TSG:*** | R2 |
|  |  |
| ***Work item code:*** | NR\_pos\_enh-Core |  | ***Date:*** | 2022-02-14 |
|  |  |  |  |  |
| ***Category:*** | B |  | ***Release:*** | Rel-17 |
|  | *Use one of the following categories:****F*** *(correction)****A*** *(mirror corresponding to a change in an earlier release)****B*** *(addition of feature),* ***C*** *(functional modification of feature)****D*** *(editorial modification)*Detailed explanations of the above categories canbe found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | *Use one of the following releases:Rel-8 (Release 8)Rel-9 (Release 9)Rel-10 (Release 10)Rel-11 (Release 11)…Rel-15 (Release 15)Rel-16 (Release 16)Rel-17 (Release 17)Rel-18 (Release 18)* |
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| ***Reason for change:*** | To capture agreements on GNSS positioning integrity into TS 38.305. |
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| ***Summary of change:*** | **RAN2#116bis**, to capture the following :* Update to definition of positioning integrity in Clause 3.1
* Integrity Principle of Operation under new Clause 8.1.1a
* New assistance data transferred from the LMF to UE on integrity in Table 8.1.2.1-1
* Integrity extensions for SSR Code Bias (8.1.2.1.23), SSR Phase Bias (8.1.2.1.24), SSR STEC Corrections (8.1.2.1.25) and SSR Gridded Corrections (8.1.2.1.26)
* Integrity Service Parameters (8.1.2.1.29), Integrity Alerts (8.1.2.1.30), Integrity Residual Risks Parameters (8.1.2.1.31), Integrity Orbit Clock Error Bounds (8.1.2.1.32)
* Mapping of integrity parameters table under new Clause 8.1.2.1b

**RAN2#116**, to capture the following :* Definition of positioning integrity captured under Clause 3.1
* General description on GNSS positioning integrity captured under Clause 8.1.1
* Descriptions on using location information transfer procedure for supporting postioning integrity captured under Clause 8.1.3.3.1
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| ***Consequences if not approved:*** | Rel-17 GNSS Positioning Integrity is not supported |
|  |  |
| ***Clauses affected:*** | 3.1, 8.1.1, 8.1.3.3.1, 8.1.1a, 8.1.2.1.23 to 8.1.2.1.26, 8.1.2.1.29 to 8.1.2.1.32, 8.1.2.1b, |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** | **X** |  |  Other core specifications  | TS/TR 38.331 CR TBDTS/TR 37.355 CR TBD |
| ***affected:*** |  | **X** |  Test specifications | TS/TR ... CR ...  |
| ***(show related CRs)*** |  | **X** |  O&M Specifications | TS/TR ... CR ...  |
|  |  |
| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** | Revision of R2-2201800 |

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# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

As used in this document, the suffixes "-based" and "-assisted" refer respectively to the node that is responsible for making the positioning calculation (and which may also provide measurements) and a node that provides measurements (but which does not make the positioning calculation). Thus, an operation in which measurements are provided by the UE to the LMF to be used in the computation of a position estimate is described as "UE-assisted" (and could also be called "LMF-based"), while one in which the UE computes its own position is described as "UE-based".

**Transmission Point (TP):** A set of geographically co-located transmit antennas (e.g. antenna array (with one or more antenna elements)) for one cell, part of one cell or one DL-PRS-only TP. Transmission Points can include base station (ng-eNB or gNB) antennas, remote radio heads, a remote antenna of a base station, an antenna of a DL-PRS-only TP, etc. One cell can include one or multiple transmission points. For a homogeneous deployment, each transmission point may correspond to one cell.

**Reception Point (RP):** A set of geographically co-located receive antennas (e.g. antenna array (with one or more antenna elements)) for one cell, part of one cell or one UL-SRS-only RP. Reception Points can include base station (ng-eNB or gNB) antennas, remote radio heads, a remote antenna of a base station, an antenna of a UL-SRS-only RP, etc. One cell can include one or multiple reception points. For a homogeneous deployment, each reception point may correspond to one cell.

**PRS-only TP:** A TP which only transmits PRS signals and is not associated with a cell.

**SRS-only RP:** An RP which only receives SRS signals and is not associated with a cell.

**Transmission-Reception Point (TRP):** A set of geographically co-located antennas (e.g. antenna array (with one or more antenna elements)) supporting TP and/or RP functionality.

**Positioning integrity:** A measure of the trust in the accuracy of the position-related data and the ability to provide associated alerts

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# 8 Positioning methods and Supporting Procedures

## 8.1 GNSS positioning methods

### 8.1.1 General

A navigation satellite system provides autonomous geo-spatial positioning with either global or regional coverage. Augmentation systems, such as SBAS, are navigation satellite systems that provide regional coverage to augment the navigation systems with global coverage.

By definition, GNSS refers to satellite constellations that achieve global coverage, however, in 3GPP specifications the term GNSS is used to encompass global, regional, and augmentation satellite systems. The following GNSSs are supported in this version of the specification:

- GPS and its modernization [5], [6], [7]; (global coverage)

- Galileo [8]; (global coverage)

- GLONASS [9]; (global coverage)

- Satellite Based Augmentation Systems (SBAS), including WAAS, EGNOS, MSAS, and GAGAN [11]; (regional coverage)

- Quasi-Zenith Satellite System (QZSS) [10]; (regional coverage)

- BeiDou Navigation Satellite System (BDS) [20] [34]. (global coverage)

Each global GNSS can be used individually or in combination with others, including regional navigation systems and augmentation systems. When used in combination, the effective number of navigation satellite signals would be increased:

- extra satellites can improve availability (of satellites at a particular location) and results in an improved ability to work in areas where satellite signals can be obscured, such as in urban canyons;

- extra satellites and signals can improve reliability, i.e., with extra measurements the data redundancy is increased, which helps identify any measurement outlier problems;

- extra satellites and signals can improve accuracy due to improved measurement geometry and improved ranging signals from modernized satellites.

When GNSS is designed to inter-work with the NG-RAN, the network assists the UE GNSS receiver to improve the performance in several respects. These performance improvements will:

- reduce the UE GNSS start-up and acquisition times; the search window can be limited and the measurements speed up significantly;

- increase the UE GNSS sensitivity; positioning assistance messages are obtained via NG-RAN so the UE GNSS receiver can operate also in low SNR situations when it is unable to demodulate GNSS satellite signals;

- allow the UE to consume less handset power than with stand-alone GNSS; this is due to rapid start-up times as the GNSS receiver can be in idle mode when it is not needed;

- allow the UE to compute its position with a better accuracy; RTK corrections (for N-RTK) and GNSS physical models (for SSR/PPP) are obtained via NG-RAN so the UE can use these assistance data, together with its own measurements, i.e., code and carrier phase measurements, to enable computation of a position with a high accuracy.

- allow the UE to determine and report the integrity results of the calculated location; the UE can use the integrity requirements and assistance data obtained via NG-RAN, together with its own measurements, to determine the integrity results of the calculated location.

The network-assisted GNSS methods rely on signalling between UE GNSS receivers (possibly with reduced complexity) and a continuously operating GNSS reference receiver network, which has clear sky visibility of the same GNSS constellation as the assisted UEs. Two assisted modes are supported:

*- UE-Assisted*: The UE performs GNSS measurements (pseudo-ranges, pseudo Doppler, carrier phase ranges, etc.) and sends these measurements to the LMF where the position calculation takes place, possibly using additional measurements from other (non GNSS) sources;

*- UE-Based*: The UE performs GNSS measurements and calculates its own location, possibly using additional measurements from other (non GNSS) sources and assistance data from the LMF.

The assistance data content may vary depending on whether the UE operates in UE-Assisted or UE-Based mode.

The assistance data signalled to the UE can be broadly classified into:

- *data assisting the measurements*: e.g. reference time, visible satellite list, satellite signal Doppler, code phase, Doppler and code phase search windows;

- *data providing means for position calculation*: e.g. reference time, reference position, satellite ephemeris, clock corrections, code and carrier phase measurements from a GNSS reference receiver or network of receivers;

- *data increasing the position accuracy*: e.g. satellite code biases, satellite orbit corrections, satellite clock corrections, atmospheric models, RTK residuals, gradients.

- *data facilitating the integrity results determination of the calculated location.*

A UE with GNSS measurement capability may also operate in an autonomous (standalone) mode. In autonomous mode the UE determines its position based on signals received from GNSS without assistance from the network.

#### 8.1.1a Integrity Principle of Operation

For integrity operation, the network will ensure that:

*P(Error > Bound | NOT DNU) <= Residual Risk + IRallocation* **(Equation 8.1.1a-1)**

for all values of IRallocation in the range irMinimum <= *IRallocation* <= irMaximum

for all the errors in Table 8.1.2.1b-1, which have corresponding integrity assistance data available and where the corresponding DNU flag(s) are set to false.

The integrity risk probability is decomposed into a constant Residual Risk component provided in the assistance data as well as a variable IRallocation component that corresponds to the contribution from the Bound according to the Bound formula in Equation 8.1.1a-2. IRallocation may be chosen freely by the client based on the desired Bound, therefore the network should ensure that Equation 8.1.1a-1 holds for all possible choices of IRallocation. The Residual Risk and IRallocation components may be mapped to fault and fault-free cases respectively, but the implementation is free to choose any other decomposition of the integrity risk probability into these two components.

Equation 8.1.1a-1 holds for all assistance data that has been issued that is still within its validity period. If this condition cannot be met then the corresponding DNU flag must be set.

Equation 8.1.1a-1 holds only at the epoch time of the DNU flag(s). The condition is not required to be met at any other times or when no DNU flags are available, i.e. DNU flags are affirmative and non-presence of the Alert IEs should not be interpreted as a usable condition. It is up to the implementation how to handle epochs for which integrity results are desired but there are no DNU flag(s) available, e.g. the Time To Alert (TTA) may be set such that there is a “grace period” to receive the next set of DNU flags.

where:

**Error:** Error is the difference between the true value of a GNSS parameter (e.g. ionosphere, troposphere etc.), and its value as estimated and provided in the corresponding assistance data as per Table 8.1.2.1b-1

**Bound:** Integrity Bounds provide the statistical distribution of the residual errors associated with the GNSS positioning corrections (e.g. RTK, SSR etc). Integrity bounds are used to statistically bound the residual errors after the positioning corrections have been applied. The bound is computed according to the Bound formula defined in Equation 8.1.1a-2. The bound formula describes a bounding model including a mean and standard deviation (e.g. paired over-bounding Gaussian). The bound may be scaled by multiplying the standard deviation by a K factor corresponding to an IRallocation, for any desired IRallocation within the permitted range.

Bound for a particular error is computed according to the following formula:

*Bound = mean + K \* stdDev* **(Equation 8.1.1a-2)**

*K = normInv(IRallocation / 2)*

*irMinimum <= IRallocation <= irMaximum*

where: *mean*: mean value for this specific error, as per Table 8.1.2.1b-1

 *stdDev*: standard deviation for this specific error, as per Table 8.1.2.1b-1

**DNU:** The DNU flag(s) corresponding to a particular error as per Table 8.1.2.1b-1. Where multiple DNU flags are specified, the DNU condition in Equation 8.1.1a-1 is present when any of the flags are true (logical OR of the flags).

**Residual Risk:** The residual risk is the component of the integrity risk provided in the assistance data as per Table 8.1.2.1b-1. This may correspond to the fault case risk but the implementation is permitted to allocate this component in any way that satisfies Equation 8.1.1a-1.

**irMinimum, irMaximum:** Minimum and maximum allowable values of IRallocation that may be chosen by the client. Provided as service parameters from the Network according to Integrity Service Parameters.

**Correlation Times:** The minimum time interval beyond which two sets of GNSS assistance data parameters for a given error can be considered to be independent from one another.

Editor's Note: The description and equation 8.1.1a-1 may be updated based on the outcome of RAN2 discussion on whether cross-covariance should be included for the Orbit and Clock integrity bounds and whether these bounds should be included as a new IE or within the existing SSR Orbit and Clock IEs

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### 8.1.2 Information to be transferred between NG-RAN/5GC Elements

This clause defines the information that may be transferred between LMF and UE.

#### 8.1.2.1 Information that may be transferred from the LMF to UE

Table 8.1.2.1-1 lists assistance data for both UE-assisted and UE-based modes that may be sent from the LMF to the UE.

NOTE: The provision of these assistance data elements and the usage of these elements by the UE depend on the NG-RAN/5GC and UE capabilities, respectively.

Table 8.1.2.1-1: Information that may be transferred from the LMF to UE

|  |
| --- |
| **Assistance Data**  |
| Reference Time |
| Reference Location |
| Ionospheric Models |
| Earth Orientation Parameters |
| GNSS-GNSS Time Offsets |
| Differential GNSS Corrections |
| Ephemeris and Clock Models |
| Real-Time Integrity |
| Data Bit Assistance |
| Acquisition Assistance |
| Almanac |
| UTC Models  |
| RTK Reference Station Information |
| RTK Auxiliary Station Data |
| RTK Observations |
| RTK Common Observation Information |
| GLONASS RTK Bias Information |
| RTK MAC Correction Differences |
| RTK Residuals |
| RTK FKP Gradients |
| SSR Orbit Corrections |
| SSR Clock Corrections |
| SSR Code Bias |
| SSR Phase Bias |
| SSR STEC Corrections |
| SSR Gridded Correction |
| SSR URA |
| SSR Correction Points |
| Integrity Service Parameters |
| Integrity Alerts |

Editor's Note: Integrity Residual Risk Parameters and Integrity Orbit Clock Error Bounds may be added to Table 8.1.2.1-1 based on the outcome of RAN2 discussion on whether the parameters will be new assistance data or integrated into existing SSR assistance data.

##### 8.1.2.1.1 Reference Time

Reference Time assistance provides the GNSS receiver with coarse or fine GNSS time information. The specific GNSS system times (e.g., GPS, Galileo, GLONASS, BDS system time) shall be indicated with a GNSS ID.

In case of coarse time assistance only, the Reference Time provides an estimate of the current GNSS system time (where the specific GNSS is indicated by a GNSS ID). The LMF should achieve an accuracy of ±3 seconds for this time including allowing for the transmission delay between LMF and UE.

In case of fine time assistance, the Reference Time provides the relation between GNSS system time (where the specific GNSS is indicated by a GNSS ID) and NG-RAN air-interface timing.

##### 8.1.2.1.2 Reference Location

Reference Location assistance provides the GNSS receiver with an a priori estimate of its location (e.g., obtained via Cell-ID, OTDOA positioning, etc.) together with its uncertainty.

The geodetic reference frame shall be WGS-84, as specified in TS 23.032 [4].

##### 8.1.2.1.3 Ionospheric Models

Ionospheric Model assistance provides the GNSS receiver with parameters to model the propagation delay of the GNSS signals through the ionosphere. Ionospheric Model parameters as specified by GPS [5], Galileo [8], QZSS [10], and BDS [20] [34] may be provided.

##### 8.1.2.1.4 Earth Orientation Parameters

Earth Orientation Parameters (EOP) assistance provides the GNSS receiver with parameters needed to construct the ECEF-to-ECI coordinate transformation as specified by GPS [5].

##### 8.1.2.1.5 GNSS-GNSS Time Offsets

GNSS-GNSS Time Offsets assistance provides the GNSS receiver with parameters to correlate GNSS time (where the specific GNSS is indicated by a GNSS-1 ID) of one GNSS with other GNSS time (where the specific GNSS is indicated by a GNSS-2 ID). GNSS-GNSS Time Offsets parameters as specified by GPS [5], Galileo [8], GLONASS [9], QZSS [10], and BDS [20] [34] may be provided.

##### 8.1.2.1.6 Differential GNSS Corrections

Differential GNSS Corrections assistance provides the GNSS receiver with pseudo-range and pseudo-range-rate corrections to reduce biases in GNSS receiver measurements as specified in [12]. The specific GNSS for which the corrections are valid is indicated by a GNSS-ID.

##### 8.1.2.1.7 Ephemeris and Clock Models

Ephemeris and Clock Models assistance provides the GNSS receiver with parameters to calculate the GNSS satellite position and clock offsets. The various GNSSs use different model parameters and formats, and all parameter formats as defined by the individual GNSSs are supported by the signalling.

##### 8.1.2.1.8 Real-Time Integrity

Real-Time Integrity assistance provides the GNSS receiver with information about the health status of a GNSS constellation (where the specific GNSS is indicated by a GNSS ID).

##### 8.1.2.1.9 Data Bit Assistance

Data Bit Assistance provides the GNSS receiver with information about data bits or symbols transmitted by a GNSS satellite at a certain time (where the specific GNSS is indicated by a GNSS ID). This information may be used by the UE for sensitivity assistance (data wipe-off) and time recovery.

##### 8.1.2.1.10 Acquisition Assistance

Acquisition Assistance provides the GNSS receiver with information about visible satellites, reference time, expected code-phase, expected Doppler, search windows (i.e., code and Doppler uncertainty) and other information of the GNSS signals (where the specific GNSS is indicated by a GNSS ID) to enable a fast acquisition of the GNSS signals.

##### 8.1.2.1.11 Almanac

Almanac assistance provides the GNSS receiver with parameters to calculate the coarse (long-term) GNSS satellite position and clock offsets. The various GNSSs use different model parameters and formats, and all parameter formats as defined by the individual GNSSs are supported by the signalling.

##### 8.1.2.1.12 UTC Models

UTC Models assistance provides the GNSS receiver with parameters needed to relate GNSS system time (where the specific GNSS is indicated by a GNSS ID) to Universal Coordinated Time. The various GNSSs use different model parameters and formats, and all parameter formats as defined by the individual GNSSs are supported by the signalling.

##### 8.1.2.1.13 RTK Reference Station Information

RTK Reference Station Information provides the GNSS receiver with the Earth-Centered, Earth-Fixed (ECEF) coordinates of the Reference Station's installed antenna's ARP, and the height of the ARP above the survey monument. Additionally, this assistance data provides information about the antenna type installed at the reference site.

NOTE: With the MAC N-RTK technique this assistance data is used to provide information regarding the Master Reference Station (see clause 8.1.2.1a).

##### 8.1.2.1.14 RTK Auxiliary Station Data

RTK Auxiliary Station Data provides the GNSS receiver with the location for all Auxiliary Reference Stations (see clause 8.1.2.1a) within the assistance data. These values are expressed as relative geodetic coordinates (latitude, longitude, and height) with respect to a Master Reference Station (see clause 8.1.2.1a) and based on the GRS80 ellipsoid. This type of assistance data is relevant only with the MAC N-RTK technique [31].

##### 8.1.2.1.15 RTK Observations

RTK Observations provides the GNSS receiver with all primary observables (pseudo-range, phase-range, phase-range rate (Doppler), and carrier-to-noise ratio) generated at the Reference Station for each GNSS signal. The signal generation from the reference station is in compliance with [31]: as an example, the phase measurements of different signals in the same band must be phased aligned. More examples can be found in [31].

The pseudo-range is the distance between the satellite and GNSS receiver antennas, expressed in metres, equivalent to the difference of the time of reception (expressed in the time frame of the GNSS receiver) and the time of transmission (expressed in the time frame of the satellite) of a distinct satellite signal.

The phase-range measurement is a measurement of the range between a satellite and receiver expressed in units of cycles of the carrier frequency. This measurement is more precise than the pseudo-range (of the order of millimetres), but it is ambiguous by an unknown integer number of wavelengths.

The phase-range rate is the rate at which the phase-range between a satellite and a GNSS receiver changes over a particular period of time.

The carrier-to-noise ratio is the ratio of the received modulated carrier signal power to the noise power after the GNSS receiver filters.

NOTE: With the MAC N-RTK technique this assistance data is used to provide raw observables recorded at the Master Reference Station (see clause 8.1.2.1a).

##### 8.1.2.1.16 RTK Common Observation Information

RTK Common Observation Information provides the GNSS receiver with common information applicable to any GNSS, e.g. clock steering indicator. This assistance data is always used together GNSS RTK Observations (see clause 8.1.2.1.15).

##### 8.1.2.1.17 GLONASS RTK Bias Information

RTK Bias Information provides the GNSS receiver with information which is intended to compensate for the first-order inter-frequency phase-range biases introduced by the reference receiver code-phase biases. This information is applicable only for GLONASS FDMA signals. In the case that the MAC Network RTK method is used, GLONASS RTK Bias Information defines the code-phase biases related to the Master Reference Station [31].

##### 8.1.2.1.18 RTK MAC Correction Differences

RTK MAC Correction Differences provides the GNSS receiver with information about ionospheric (dispersive) and geometric (non-dispersive) corrections generated between a Master Reference Station and its Auxiliary Reference Stations [31].

##### 8.1.2.1.19 RTK Residuals

RTK Residuals provides the GNSS receiver with network error models generated for the interpolated corrections disseminated in Network RTK techniques. With sufficient redundancy in the RTK network, the location server process can provide an estimate for residual interpolation errors. Such quality estimates may be used by the target UE to optimize the performance of RTK solutions. The values may be considered by the target UE as a priori estimates only, with sufficient tracking data available the target UE might be able to judge residual geometric and ionospheric errors itself. According to [31], RTK Residual error information should be transmitted every 10-60 seconds.

##### 8.1.2.1.20 RTK FKP Gradients

RTK FKP Gradients provides the GNSS receiver with horizontal gradients for the geometric (troposphere and satellite orbits) and ionospheric signal components in the observation space. According to [31], RTK FKP gradient information should be typically transmitted every 10-60 seconds.

##### 8.1.2.1.21 SSR Orbit Corrections

SSR Orbit Corrections provides the GNSS receiver with parameters for orbit corrections in radial, along-track and cross-track components. These orbit corrections are used to compute a satellite position correction, to be combined with satellite position ­calculated from broadcast ephemeris (see clause 8.1.2.1.7).

##### 8.1.2.1.22 SSR Clock Corrections

SSR Clock Corrections provides the GNSS receiver with parameters to compute the GNSS satellite clock correction applied to the broadcast satellite clock (see clause 8.1.2.1.7). A polynomial of order 2 describes the clock differences for a certain time period: clock offset, drift, and drift rate.

##### 8.1.2.1.23 SSR Code Bias

SSR Code Bias provides the GNSS receiver with the Code Biases that must be added to the pseudo range measurements of the corresponding code signal to get corrected pseudo ranges. SSR Code Bias contains absolute values, but also enables the alternative use of Differential Code Biases by setting one of the biases to zero. A UE can consistently use signals for which a code bias is transmitted. It is not reliable for a UE to use a signal without retrieving a corresponding code bias from the assistance data message. For integrity purposes, SSR Code Bias also provides the mean and standard deviation that bounds the residual Code Bias Error and its associated error rate.

##### 8.1.2.1.24 SSR Phase Bias

SSR Phase Bias provides the GNSS receiver with the GNSS signal phase bias that are added to the carrier phase measurements of the corresponding signal to get corrected phase ranges. An indicator used to count events when phase bias is discontinuous is provided. An optional indicator is also provided to indicate whether fixed, widelane fixed or float PPP-RTK positioning modes are supported on a per signal basis.

NOTE 1: On the UE side, phase bias corrections of appropriate type are needed to restore the integer nature of the phase ambiguities in PPP-RTK. Their absence will affect the quality of the positioning solution and prevent a fast convergence time.

NOTE 2: PPP-RTK Fixed position mode corresponds to the UE fixing the carrier phase ambiguity to an integer value. The PPP-RTK Widelane Fixed positioning mode corresponds to forming the widelane combination of carrier phase measurements and fixing the resulting ambiguity as an integer value. In PPP-RTK Float positioning mode the carrier phase ambiguity is not treated as an integer value.

For integrity purposes, SSR Phase Bias also provides the mean and standard deviation that bounds the residual Phase Bias Error and its associated error rate.

##### 8.1.2.1.25 SSR STEC Corrections

SSR STEC Corrections provides the GNSS receiver with the parameters to compute the ionosphere slant delay correction based on a variable order polynomial on a per satellite basis and applied to the code and phase measurements.

For integrity purposes, SSR STEC Corrections also provides the ionosphere residual risk parameters, correlation time for ionosposphere range error and range error rate, and the mean and standard deviation that bounds the residual Ionospheric Error and its associated error rate.

##### 8.1.2.1.26 SSR Gridded Correction

SSR Gridded Corrections provides the GNSS receiver with STEC residuals and Troposphere delays at a series of correction points and expressed as hydrostatic and wet vertical delays.

NOTE: The final ionosphere slant delay (STEC) consists of the polynomial part provided in SSR STEC Correction and the residual part provided in SSR Gridded Corrections.

For integrity purposes, SSR Gridded Corrections also provides the troposphere residual risk parameters, correlation time for troposphere range error and range error rate, and the mean and standard deviation that bounds the residual Tropospheric Error and associated its error rate in the Vertical Hydro Static Delay and Vertical Wet Delay components.

##### 8.1.2.1.27 SSR URA

SSR URA provides the receiver with information about the estimated accuracy of the corrections for each satellite.

##### 8.1.2.1.28 SSR Correction Points

The SSR Correction Points provides a list of correction point coordinates or an array of correction points ("grid") for which the SSR Gridded Corrections are valid.

##### 8.1.2.1.29 Integrity Service Parameters

Integrity Service Parameters provide the range of Integrity Risk (IR) for which the associated GNSS integrity assistance data is considered to be valid.

##### 8.1.2.1.30 Integrity Alerts

Integrity Service Alerts provide information on whether the service can be used for integrity. A Do Not Use (DNU) flag indicates that the corresponding assistance data is not suitable for the purpose of computing integrity. If no DNU flag is issued, then the corresponding assistance data may be used for the purpose of computing integrity. The DNU flags are defined to be applicable to the specified epoch time only.

##### 8.1.2.1.31 Integrity Residual Risk Parameters

Integrity Residual Risk Parameters are used to provide the residual risk parameters related to the satellite, constellation, ionosphere and troposphere residual risk probabilities. These parameters include a Probability of Onset which is defined per unit of time and represents the probability that the feared event begins. The Mean Duration represents the expected mean duration of the corresponding feared event and is used to convert the Probability of Onset to a probability that the feared event is present at any given time, i.e.

 *P(Feared Event is Present) = Mean Duration \* Probability of Onset of Feared Event* **(Equation 8.1.2.1.31-1)**

##### 8.1.2.1.32 Integrity Orbit Clock Error Bounds

Integrity Orbit Clock Error Bounds is used to provide integrity bounding parameters relating to the orbit, orbit rate, clock and clock rate residual errors after application of the SSR corrections. The correlation times for the orbit range error, orbit range rate error, clock range and clock range rate error are also provided.

#### 8.1.2.1a Recommendations for grouping of assistance data to support different RTK service levels

This clause provides recommendations for the different high-accuracy GNSS service levels: RTK, N-RTK, PPP and PPP-RTK.

The high-accuracy GNSS methods can be classified as:

- Single base RTK service: RTK is a technique that uses carrier-based ranging measurements i.e., phase-range to improve the positioning accuracy in a differential approach. The basic concept is to reduce and remove errors common to a Reference Station, with known position, and UE pair. When only pseudo ranges (code-based measurements) are used to compute the UE location, this method is known as DGNSS (Differential GNSS).

Table 8.1.2.1a-1: Single base RTK service: Specific information that may be transferred from the LMF to the UE

|  |
| --- |
| **Assistance Data**  |
| RTK Reference Station Information |
| RTK Observations |
| RTK Common Observation Information |
| GLONASS RTK Bias Information (if GLONASS data is transmitted) |
| Ephemeris and Clock (if UE did not acquire the navigation message) |

- *Non-Physical Reference Station Network RTK service*: In this approach the target UE receives synthetic observations from a fictitious Reference Station. The Network RTK software at the location server is performing the error estimation and creates a virtual Reference Station close to the initial location of the target device (provided a priori to the location server). The target UE interprets and uses the data just as if it had come from a single, real Reference Station. Additionally, the target UE can also receive network information such as RTK Network Residuals (see clause 8.1.2.1.19) or even FKP gradients (see clause 8.1.2.1.20).

Table 8.1.2.1a-2: Non-Physical Reference Station Network RTK service: Specific information that may be transferred from the LMF to the UE

|  |
| --- |
| **Assistance Data**  |
| RTK Reference Station Information |
| RTK Observations |
| RTK Common Observation Information |
| GLONASS RTK Bias Information (if GLONASS data is transmitted) |
| RTK Residuals |
| RTK FKP Gradients |
| Ephemeris and Clock (if UE did not acquire the navigation message) |

- *MAC Network RTK service*: In MAC network RTK, a group of Reference Stations are used and one of them is chosen as a Master station. The other stations are then called Auxiliary stations. In this service, the location server sends full raw observations and coordinate information for a single Reference Station, the Master Station. For all auxiliary stations in the network (or a suitable subset of stations) the information is provided to the UE in a highly compact form: their reduced ambiguity-levelled observations, coordinate differences (to the Master Station observations and coordinates), and network residuals. Two Reference Stations are said to be on a common ambiguity level if the integer ambiguities for each phase range (satellite-receiver pair) have been removed (or adjusted) so that the integer ambiguities cancel when double-differences (involving two receivers and two satellites) are formed during processing. The maintenance of a common ambiguity level at a specific set of stations rather than across the whole GNSS network will lead to a grouping in network clusters or subnetworks of all ambiguity-levelled Reference Stations. If one network has only one subnetwork, this indicates that an ambiguity level throughout the whole network is established. When subnetworks are predefined, the assistance data can be broadcast to all UEs located in the assigned sub-network. More details on the usage of subnetworks can be found in [31].

Table 8.1.2.1a-3: MAC Network RTK service: Specific Information that may be transferred from the LMF to the UE

|  |
| --- |
| **Assistance Data**  |
| RTK Reference Station Information |
| RTK Auxiliary Station Data |
| RTK Observations |
| RTK Common Observation Information |
| GLONASS RTK Bias Information (if GLONASS data is transmitted) |
| RTK MAC Correction Differences |
| RTK Residuals |
| Ephemeris and Clock (if UE did not acquire the navigation message) |

- *FKP Network RTK service*: With the concept of FKP, horizontal gradients of distance-dependent errors like ionosphere, troposphere and orbits are derived from a network of GNSS Reference Stations and transmitted to a target device together with raw or correction data of a corresponding Reference Station (physical or non physical). The target UE may use the gradients to compute the effect of the distance-dependent errors for its own position.

Table 8.1.2.1a-4: FKP Network RTK service: Information that may be transferred from the LMF to the UE

|  |
| --- |
| **Assistance Data**  |
| RTK Reference Station Information |
| RTK Observations |
| RTK Common Observation Information |
| GLONASS RTK Bias Information (if GLONASS data is transmitted) |
| RTK Residuals |
| RTK FKP Gradients |
| Ephemeris and Clock (if UE did not acquire the navigation message) |

- *PPP service*: This concept uses precise satellite orbit and clock parameters derived from global networks of Reference Stations as well as atmospheric models to perform single station positioning [31]. Compared to RTK and Network RTK, PPP is not a differential technique as there is no baseline limitation. When the orbits and clocks assistance data elements are provided in real-time, with no latency, the method is called Real-Time PPP.

Table 8.1.2.1a-5: SSR PPP service: Information that may be transferred from the LMF to the UE

|  |
| --- |
| **Assistance Data**  |
| SSR Orbit Corrections |
| SSR Clock corrections |
| SSR Code Bias |
| Ephemeris and Clock (if UE did not acquire the navigation message) |

- *PPP-RTK service*: This concept uses precise satellite orbits and clock parameters, the satellite signal biases derived from global networks of Reference Stations as well as ionosphere and troposphere corrections to perform single station positioning IS-QZSS-L6-001 [36]. Therefore, PPP-RTK services compensate the global and local corrections for a more accurate location information. Compared to PPP, PPP-RTK requires the UE to be located within the region covered by the ionosphere and troposphere corrections.

Table 8.1.2.1a-6: SSR PPP-RTK service: Information that may be transferred from the LMF to the UE

|  |
| --- |
| **Assistance Data**  |
| SSR Orbit Corrections |
| SSR Clock corrections |
| SSR Code Bias |
| Ephemeris and Clock (if UE did not acquire the navigation message) |
| SSR Phase Bias |
| SSR STEC Corrections |
| SSR Gridded Correction |
| SSR URA |
| SSR Correction Points |

#### 8.1.2.1b Mapping of integrity parameters

Table 8.1.2.1b-1 shows the mapping between the integrity fields and the SSR assistance data according to the Integrity Principle of Operation (Clause 8.1.1a). The corresponding field descriptions for each of the field names listed in Table 8.1.2.1b-1 are specified under Clause 6.5.2.2 of TS 37.355 (LPP).

Table 8.1.2.1b-1: Mapping of Integrity Parameters

|  |  |  |
| --- | --- | --- |
| **Error** | **GNSS Assistance Data** | **Integrity Fields** |
| **Integrity Alerts** | **Integrity Bounds (Mean)** | **Integrity Bounds (StdDev)** | **Residual Risks** | **Integrity Correlation Times** |
| Orbit | SSR Orbit Corrections |  |  |  | Probability of Onset of Constellation FaultProbability of Onset of Satellite FaultMean Constellation Fault DurationMean Satellite Fault Duration | Orbit Range Error Correlation TimeOrbit Range Rate Error Correlation Time |
| Clock | SSR Clock Corrections | Clock Range Error Correlation TimeClock Range Rate Error Correlation Time |
| Code Bias | SSR Code Bias | Mean Code Bias Error Mean Code Bias Rate Error | Standard Deviation Code Bias Error Standard Deviation Code Bias Rate Error |  |
| Phase Bias | SSR Phase Bias | Mean Phase Bias Error Mean Phase Bias Rate Error | Standard Deviation Phase Bias ErrorStandard Deviation Phase Bias Rate Error |
| Ionosphere | SSR STEC CorrectionSSR Gridded Correction | Ionosphere DNU | Mean Ionospherre Error Mean Ionospherre Rate Error | Standard Deviation Ionosphere ErrorStandard Deviation Ionosphere Rate Error | Probability of Onset of Ionosphere FaultMean Ionosphere Fault Duration | Ionosphere Range Error Correlation TimeIonosphere Range Rate Error Correlation Time |
| Troposphere Vertical Hydro Static Delay | SSR Gridded Corrections | Troposphere DNU | Mean Troposphere Vertical Hydro Static Delay ErrorMean Troposphere Vertical Hydro Static Delay Rate Error | Standard Deviation Troposphere Vertical Hydro Static Delay ErrorStandard Deviation Troposphere Vertical Hydro Static Delay Rate Error | Probability of Onset of Troposphere FaultMean Troposphere Fault Duration | Troposphere Range Error Correlation TimeTroposphere Range Rate Error Correlation Time |
| TroposphereVertical WetDelay | Mean Troposphere Vertical Wet Delay ErrorMean Troposphere Vertical Wet Delay Rate Error | Standard Deviation Troposphere Vertical Wet Delay ErrorStandard Deviation Troposphere Vertical Wet Delay Rate Error |

Editor's Note: Integrity Orbit Clock Error Bounds may be added based on the outcome of RAN2 discussion on whether the parameters will be new assistance data or integrated into existing SSR assistance data.

<<<<<<<<<<<<<<<<<<<< Third change ends >>>>>>>>>>>>>>>>>>>>

<<<<<<<<<<<<<<<<<<<< Fourth change begins >>>>>>>>>>>>>>>>>>>>

#### 8.1.3.3 Location Information Transfer Procedure

The purpose of this procedure is to enable the LMF to request position measurements or location estimate from the UE, or to enable the UE to provide location measurements to the LMF for position calculation.

##### 8.1.3.3.1 LMF initiated Location Information Transfer Procedure

Figure 8.1.3.3.1-1 shows the Location Information Transfer operations for the network-assisted GNSS method when the procedure is initiated by the LMF.



Figure 8.1.3.3.1-1: LMF-initiated Location Information Transfer Procedure

(1) The LMF sends a LPP Request Location Information message to the UE for invocation of A-GNSS positioning. This request includes positioning instructions such as the GNSS mode (UE-assisted, UE-based, UE-based preferred but UE-assisted allowed, UE-assisted preferred, but UE-based allowed, standalone), positioning methods (GPS, Galileo, GLONASS, BDS, etc. and possibly non-GNSS methods, such as OTDOA positioning or E-CID positioning), specific UE measurements requested if any, such as fine time assistance measurements, velocity, carrier phase, multi-frequency measurements, quality of service parameters (accuracy, response time) , and possibly integrity requirements.

(2) The UE performs the requested measurements and possibly calculates its own location. The UE may also determine the integrity results of the calculated location. The UE sends an LPP Provide Location Information message to the LMF before the Response Time provided in step (1) elapsed. If the UE is unable to perform the requested measurements, or if the Response Time provided in step 1 elapsed before any of the requested measurements have been obtained, the UE returns any information that can be provided in an LPP message of type Provide Location Information which includes a cause indication for the not provided location information.

##### 8.1.3.3.2 UE-initiated Location Information Delivery Procedure

Figure 8.1.3.3.2-1 shows the Location Information delivery operations for the UE-assisted GNSS method when the procedure is initiated by the UE.



Figure 8.1.3.3.2-1: UE-initiated Location Information Delivery Procedure

(1) The UE sends an LPP Provide Location Information message to the LMF. The Provide Location Information message may include any UE measurements (GNSS pseudo-ranges, carrier phase-ranges, and other measurements) already available at the UE.

<<<<<<<<<<<<<<<<<<<< Fourth change ends >>>>>>>>>>>>>>>>>>>>

# Annex-Agreements on GNSS Positioning Integrity

### 3GPP TSG-RAN WG2 Meeting #114-e R2-21xxxxx

Agreement:

Proposal 1 (modified): RAN2 confirms that LPP messages RequestCapabilities and ProvideCapabilities are used to transfer capability information of GNSS positioning integrity support. FFS the contents of capability information for GNSS positioning integrity support.

### 3GPP TSG-RAN WG2 Meeting #115-e R2-2108835

Agreements:

Proposal 1: Agree that the GNSS feared events will be addressed in the WI.

Proposal 2 (modified): Agree that all for A-GNSS positioning methods, positioning integrity determination is supported in LPP.

Proposal 3: Agree that additional IEs are needed in LPP to support A-GNSS positioning integrity determination.

Proposal 4: The specific algorithms used for positioning integrity shall be up to implementation.

Proposal 5: For interoperability, the use of “hard-coded” parameters should be minimized and instead the needed parameters should be sent explicitly in the assistance data.

Proposal 6: RAN2 agrees that the PL will be reported in the Integrity Results. It is FFS whether Mode 2 and the TIR, AL, TTA that were used in the integrity calculation will also be reported in the integrity results.

Proposal 8: Agree that the UE feared events will be handled in the implementation for UE-based (network-assisted) methods of positioning integrity determination.

Proposal 10: Agree that the LMF feared events can be handled via implementation for the UE-based (network-assisted) and UE-assisted (LMF-based) methods of positioning integrity determination.

Proposal 11: RAN2 agrees to use Common Positioning IEs to transfer the KPIs and Integrity Results.

Proposal 12: RAN2 agrees that the LPP procedures can be used to transfer the KPIs and Integrity Results. For UE-assisted, the LCS procedures remain FFS in the case of MO-LR.

Agreements:

In Rel-17, we do not address the data transmission feared event (i.e. we rely on the system’s existing methods for assuring data integrity).

Agreements:

Proposal 1: The support of GNSS integrity is enabled by using existing NG-RAN positioning architecture.

Proposal 2: Any additional functional elements, positioning/integrity modes, etc. should be introduced only when needed.

Agreements:

Proposal 3 (modified): Separate procedures for "A-GNSS Positioning Integrity" as proposed in R2-2107503 will not be defined; the existing A-GNSS (and general location) Procedures are applicable/sufficient.

Proposal 4 (modified): RAN2 confirms that LPP messages RequestLocationInformation and ProvideLocationInformation are used to transfer integrity KPIs/results, respectively, for GNSS positioning at least for UE-based mode.

Proposal 5 (modified): RAN2 confirms that LPP messages RequestAssistanceData and ProvideAssistanceData are used to transfer integrity assistance data for GNSS positioning at least for UE-based mode.

### 3GPP TSG-RAN WG2 Meeting #116-e R2-211xxxx

Agreements:

Proposal 1. Request feedback from RTCM SC134 on the specific technical attributes:

- overbounding of GNSS errors: zero-mean assumption (provision of standard deviation only) or non-zero mean assumption (provision of mean in addition to standard deviation); paired overbounding vs single overbounding.

- additional items are FFS for now and depend on progress during RAN2 #116.

Proposal 2. RAN2 to proceed with the Rel-17 work scope. What is achieved is FFS and depends on contributions and proposals under discussions in R2-2110181.

Proposal 3. RAN2 agrees to leverage in the future on standards for GNSS integrity message produced by RTCM SC134 when this become available.

Proposal 4. Include in the draft LS all our agreements/conclusions dealing with GNSS integrity.

Agreements:

Proposal1-1 (modified): WA: The paired overbounding technique is supported for bounding the error probability distribution for GNSS integrity as a baseline.

Proposal1-2 (modified): Error representation by SSR is supported for GNSS integrity. FFS alignment with the assistance data for OSR in RTCM (also FFS alignment with SSR, if RTCM produce something in that direction in the Rel-17 time frame).

Agreements:

Proposal2-9: Assistance data for GNSS integrity can be sent periodically.

Proposal2-11: The assistance data in GNSS-RealTimeIntegrity can be reused for GNSS integrity in R17

Agreement:

Pursue LMF-based integrity on a best-effort basis in Rel-17.

### 3GPP TSG-RAN WG2 Meeting #116bis-e R2-211xxxx

Agreements:

Proposal 1: RAN2 agrees to add the Integrity Principle of Operation (Clause 8.1.1a) text from Appendix A (R2-2201761) into TS 36.305 and TS 38.305.

Proposal 2: Agree to add the descriptions from Appendix A (R2-2201761) for the SSR Code Bias (8.1.2.1.23), SSR Phase Bias (8.1.2.1.24), SSR STEC Corrections (8.1.2.1.25) and SSR Gridded Corrections (8.1.2.1.26) as baseline. Final wording is subject to the outcomes of Stage 3 and depends on which integrity IEs and associated fields are included in LPP.

Proposal 3: Agree to add the Integrity Service Parameters (8.1.2.1.29) and Integrity Alerts (8.1.2.1.30) descriptions from Appendix A (R2-2201761) into TS 36.305 and TS 38.305.

Proposal 4: RAN2 agrees to include the description for the Orbit Clock Error Bounds, as per Appendix A (R2-2201761), but the final description is FFS subject to the Stage 3 discussions on whether option (b), (c) or (d) is preferred (or another alternative):

(b) Duplicate within the SSR Orbit and Clock IEs (NW determines which to include).

(c) Add orbit and clock integrity bounds (mean, sigma) to the existing Orbit and Clock IEs (but without the full covariance).

(d) Define a separate message as a new IE (i.e. a combined message for the Orbit Clock Error Bounds).

Proposal 5: RAN2 agrees to include the Integrity Residual Risk Parameters into their existing corresponding GNSS IEs (as per Appendix A (R2-2201761). This discussion is also subject to the Stage 3 outcomes regarding which IEs and associated fields to define for integrity.

Proposal 6: Agree to add Section 8.1.2.1b-1 and Table 8.1.2.1b-1 (as per Appendix A (R2-2201761)) into TS 36.305 and TS 38.305. The field names in Table 8.1.2.1b-1 are subject to the outcomes of Stage 3 regarding which integrity IEs and associated fields to include in LPP.

Agreements:

 Proposal 1: Agree to add a new IE for the Integrity Service Parameters which contains the irMinimum and irMaximum fields. The IE will be included under GNSS-CommonAssistData.

 Proposal 2: Agree to add a new IE for Integrity Service Alerts under GNSS-CommonAssistData which contains the Ionosphere DNU and Troposphere DNU.

 FFS on whether to also include the Service DNU.

 Proposal 4: Agree to add the Mean and Standard Deviation parameters for the Integrity Bounds within the existing SSR-Code-Bias, SSR-Phase-Bias, SSR-STEC-Correction and SSR-GriddedCorrection IEs in LPP, as per Table 3.2-1 in R2-2201765.

 Proposal 6: RAN2 agrees to update Stage 2 with a description of the Mean Fault Duration parameters. The following changes are proposed in addition to the Stage 2 text updates that were agreed in R2-2201765, for inclusion into the running Stage 2 CR:

[Chair’s note: See R2-2201765 for the properly formatted and change-marked version of this agreement]

8.1.2.1.31 Integrity Residual Risk Parameters

Integrity Residual Risk Parameters are used to provide the residual risk parameters related to the satellite, constellation, ionosphere and troposphere residual risk probabilities. These parameters include a Probability of Onset which is defined per unit of time and represents the probability that the feared event begins. The Mean Duration represents the expected mean duration of the corresponding feared event and is used to convert the Probability of Onset to a probability that the feared event is present at any given time, i.e.

P(Feared Event is Present)= Mean Duration\*Probability of Onset of Feared Event

 Proposal 8: Agree to include the Integrity Correlation Times parameters from Table 3.2-3 (R2-2201765) within the SSR-STEC-Correction and SSR-GriddedCorrection IEs in LPP, with updated field names as follows:

 tCorrelationIonosphere changed to ionoRangeErrorCorrelationTime

 tCorrelationIonosphereRate changed to ionoRangeRateErrorCorrelationTime

 tCorrelationTroposphere changed to tropoRangeRateErrorCorrelationTime

 tCorrelationTroposphereRate changed to tropoRangeRateErrorCorrelationTime

Agreements:

Introduce a new posSIB for the new assistance data added for integrity.